WORLD animal REVIEW

a quarterly journal on animal health, production and products

30

COMMENT

The spread of African Swine Fever

For over 70 years African swine fever (ASF) has been known to be endemic in Africa south of the Sahara. During this period outbreaks of the disease have occurred in France, peninsular Italy, Spain, Portugal, Cuba. During 1978 the disease spread to Malta and the Italian island of Sardinia; and to Brazil and the Dominican Republic. Early in the present year its presence in Haiti was confirmed.

It is still present in Spain, Portugal, Sardinia, Brazil, the Dominican Republic and Haiti. It was eradicated from France, peninsular Italy, Cuba and Malta, in some cases with heavy losses and the necessary slaughter of entire pig populations.

ASF is a highly contagious viral disease generally considered the most serious of all pig diseases. Its symptoms and lesions are similar to those not only of classical swine fever (hog cholera) but of salmonelloses and erysipelas. It is often mistaken for classical swine fever (hog cholera) although it is caused by a different virus. In Africa mortality rates have always been very high but in the Iberian peninsula and in recently infected countries in Latin America, a proportion of animals have recovered, becoming carriers of the disease.

ASF is spread by contaminated garbage, water or feed; contact between infected and susceptible pigs; carrier animals; contaminated premises, clothing, footwear and equipment; incorrect methods of disposing of infected carcasses; movement of exposed or infected pigs; contact with infected wart-hogs or wild pigs and arthropod vectors such as soft ticks. The virus is exceptionally resistant and difficult to inactivate.

The countries surrounding or adjacent to those infected are now at great risk. Many of them have large numbers of pigs kept mainly by small farmers. The effects of outbreaks on the economic well-being of such farmers and on the meat supplies of the country concerned may be catastrophic.

With the growth and development of international air traffic and the presence of a number of infected countries on air routes the danger of the spread of the disease through contaminated garbage is very real.

Because ASF is similar to classical swine fever (hog cholera), rapid laboratory diagnosis is the key to its control and eradication; in addition, the field staff of a country's veterinary service must also know how to deal with outbreaks as soon as they are diagnosed.

Furthermore, it is vitally important that countries not at present infected with ASF should now take strong preventive measures in regard to traffic coming from countries having the disease.

Unfortunately, very few countries at risk have all the requirements available, such as diagnostic facilities, trained staff, organization, and equipment, necessary to enable them to deal efficiently with outbreaks of diseases of this kind.

Costs of control and eradication are high (to eradicate the disease in Spain, for example, would cost at least US$114 million) but the only alternative — to live with the disease — means, in many countries, the loss of the pig industry of the country concerned.

A policy of prevention is, therefore, the right policy to adopt by a country at risk. This means that measures have to be taken to prevent entry of contaminated material; ensure the rapid diagnosis of the disease if it occurs; apply immediately a policy of stamping out the disease should it be diagnosed; and take strict precautionary measures thereafter.

Because of the seriousness of the situation in Latin America, FAO, in collaboration with the Pan-American Health Organization, convened an Emergency Expert Consultation, which was held in Lima, Peru, in July 1978. This was followed by the FAO Regional Conference for Latin America held at Montevideo, Uruguay, in August 1978, which requested FAO to assume the leadership in working out the strategies now necessary to control and eradicate the disease.

Since July 1978, FAO has committed over US$1 million from its Technical Cooperation Programme for equipment, consultancies, and training programmes in 12 countries. Other programmes organized by FAO include regional training courses and technical meetings, technical assistance missions to countries, and the implementation of subregional ASF control projects.

Other plans being developed include the establishment of a regional ASF reference centre and a scheme to help prevent the spread of ASF and other exotic diseases of economic importance as well as for coping with emergency situations.

(A review article on African swine fever to appear in a forthcoming issue of the World Animal Review is now in course of preparation.)

WORLD

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COVER: Handmilking a Surti buffalo (Photo: Anand Cooperative, Gujarat, India).

Buffalo milk technology

N.C. Ganguli

In many developing countries the significance of the buffalo as a milk producer is now well established. For example, 55 percent of the total milk produced in India comes from buffaloes. Cockrill (1974) highlighted its status as a companion animal to the cow in many Southeast Asian countries. In recent years, the Indian Council of Agricultural Research (ICAR) has established buffalo research projects to improve the breeding of buffaloes for milk production. ICAR has also decided to set up the Central Institute for Research on Buffaloes. The importance of the buffalo as a milk-producing animal in India, Egypt and Pakistan has been the subject of a number of publications (e.g., Dastur, 1956; Fahimuddin, 1975).

Some 88 percent of the world production of buffalo milk comes from countries in Asia and the Far East. In 1976 the production in these countries amounted to about 21 million tons, of which just over 16 million tons were produced by India.

Buffalo milk, being significantly different in composition from cow milk, has posed a number of technological problems in its processing for the manufacture of dairy products. Until about a decade ago it was felt that buffalo milk was probably not suitable for the manufacture of dairy products, mainly because the existing technology for processing cow milk proved unsuitable for buffalo milk. As a result, new methods had to be found and today milk products such as butter, cheese, condensed milk, skim milk powder, infant food and fermented milk products are being successfully manufactured from buffalo milk, in addition to a wide range of indigenous milk products. Some states in India process buffalo milk only, while others process both buffalo and cow milk. This article describes some aspects of buffalo milk technology.

Gross composition

Some thorough reviews have been published on the composition of buffalo milk and milk products (Dastur, 1956; Laxminarayanan and Dastur, 1968) and on recent trends in research on buffalo milk (Dastur *et al.*, 1971; Ganguli, 1968, 1973, 1974a, 1974b, 1978; Hofi, Rifaat and Khorshid, 1966). Different descriptions have been given of the chemical composition of buffalo milk from countries such as Bulgaria, Egypt, India, Italy and the USSR (Dastur *et al.*, 1971; Laxminarayanan and Dastur, 1968; Ganguli, 1974a). A summary of the average values of the major constituents of buffalo milk reported by some of these workers is given in Table 1. Buffalo milk is richer than cow milk in milk fat; it also has higher levels of protein, lactose and ash, though the latter differences are not as great as those of fat (Figure 1). The absence in buffalo milk of β-carotene, which is present in cow milk, is another notable characteristic.

Of all the breeds, the milk of the Murrah buffalo in India has been studied in the greatest detail (Ganguli, 1974a). The milk produced by animals of this breed has been found to vary in composition between localities and between feeding regimes.

In this context it should be noted that protein-fat and casein-fat numbers for buffalo milk are less than those for cow milk; there is a significant correlation between pH and solids-not-fat (SNF), pH and lactose, fat and SNF but not between pH, fat and protein. Buffalo milk has a higher pH, higher viscosity, more curd tension, less rennet clotting time and lower heat stability than cow milk. Homogenization reduces the curd tension of buffalo milk by about 70 percent whereas its relative viscosity increases.

Casein in buffalo milk exists primarily in micellar form; soluble casein as found in cow milk is almost absent. Electron microscopy has shown that, compared with micelles in cow milk, the casein micelles in buffalo milk are larger in size, more opaque, contain less nitrogen, less sialic acid, but more calcium and phosphorus (Figure 2). Buffalo milk K-casein possesses less stabilizing ability toward α_s-casein than cow K-casein. The proportion of

TABLE 1. **Composition of buffalo milk**

Country	Number of samples	Fat	SNF	Total solids	Total protein	Lactose	Ash
		. . . .	Percentage	. . . .			
Bulgaria	—	7.50	9.88	17.38	4.10	4.78	0.73
Egypt	700	6.37	10.03	16.40	3.87	—	—
Egypt	72	6.53	—	—	3.78	5.00	0.79
Egypt	—	6.80	9.80	16.60	4.10	4.50	0.80
India	—	7.21	9.86	17.07	—	—	—
India	127	6.80	9.61	—	3.91	[1] 5.70	—
India	—	7.06	10.50	17.56	4.65	5.07	0.78
Italy	132	7.22	9.64	—	3.95	4.88	—
USSR	27	6.10	—	18.00	4.32	4.96	0.84

Source: Laxminarayanan and Dastur (1968).
NOTE: — = not available or not calculated.
[1] Includes ash.

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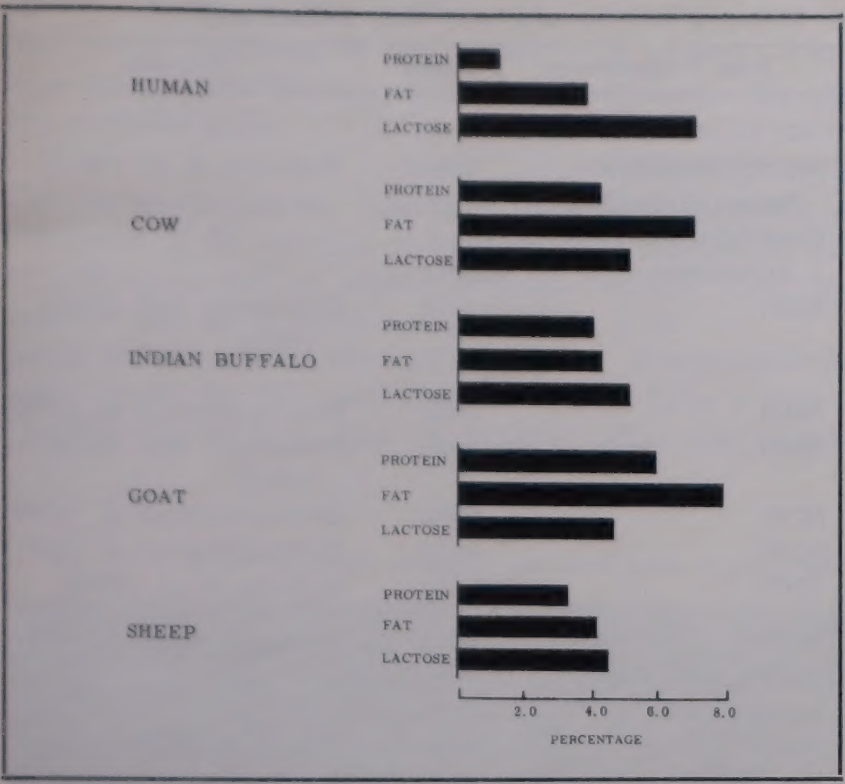


Figure 1 *Composition of milk from different sources*

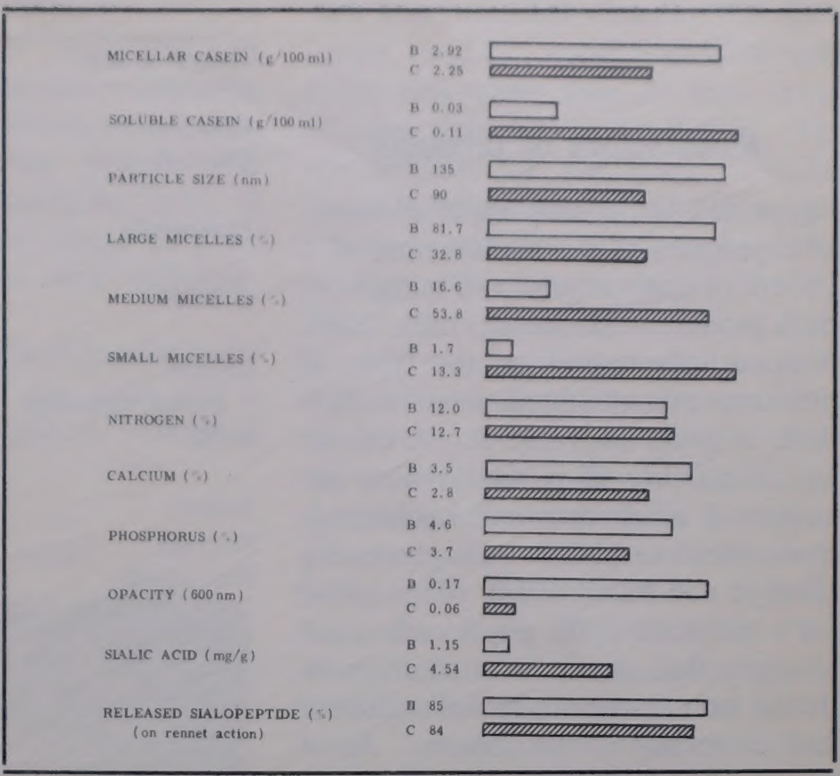


Figure 2 *Comparison of the casein micelles in buffalo (B) and cow (C) milk*

α-lactalbumin and immunoglobulin is greater in buffalo milk than in cow milk, the reverse being true for β-lactoglobulin and serum proteins. Most of the milk enzymes and proteose-peptones are found in buffalo milk at a lower concentration than in cow milk (Ganguli, 1974a).

Fat globules in buffalo milk are larger than in cow milk and buffalo milk fat shows a higher density, a higher melting point and a lower iodine value than cow milk fat (Table 2). It is more resistant to oxidative changes, and is richer in butyric acid and long-chain fatty acids such as palmitic and stearic acid. The calcium content is higher in buffalo milk than in cow milk and it contains more colloidal calcium and phosphorus. In general, buffalo milk has a greater concentration of cations than anions compared with cow milk (Figure 3).

TABLE 2. **Analytical constants of buffalo milk fat compared with cow milk fat**

Constant	Buffalo milk fat	Cow milk fat
Butyrorefractometer index	42.0	41.2
Saponification value	230.1	227.3
Reichert value	32.3	26.67
Polenske value	1.41	1.76
Kirchner value	28.52	22.15
Iodine value	29.43	33.78
Solidifying point (°C)	16.8-28.0	15.8-25.5
Melting point (°C)	32.0-43.5	28.5-41.0
Colour (Yellow units/g Tintometer)	0.8	8.8

Source: Ganguli (1974a).

Salt balance and heat stability

The heat stability of buffalo milk has been studied in relation to its salt balance. The ratio of Ca+Mg to phosphate and citrate has been found to be 8.66 for buffalo milk and 0.47 for cow milk. The corresponding ratios for the soluble and ionic fractions of Ca+Mg to phosphate + citrate are 0.70 and 0.31 for buffalo milk and 0.33 and 0.13 for cow milk respectively. The high ratios found for buffalo milk provide indirect evidence of its poor heat stability. When the milk is heated, the values decrease more in buffalo milk than in cow milk; this effect is accentuated by prewarming. The soluble salts were found to affect heat stability (Ismail, Salam and Sirry, 1971).

Balachandran and Srinivasan (1974) studied the effect of electrometathesis on the heat stability of buffalo milk. Milk standardized to a fat:SNF ratio of 1 : 2.44 was subjected to a replacement of calcium ions by sodium ions. Such replacement of up to 25 percent of the calcium ions progressively increased the heat stability of buffalo

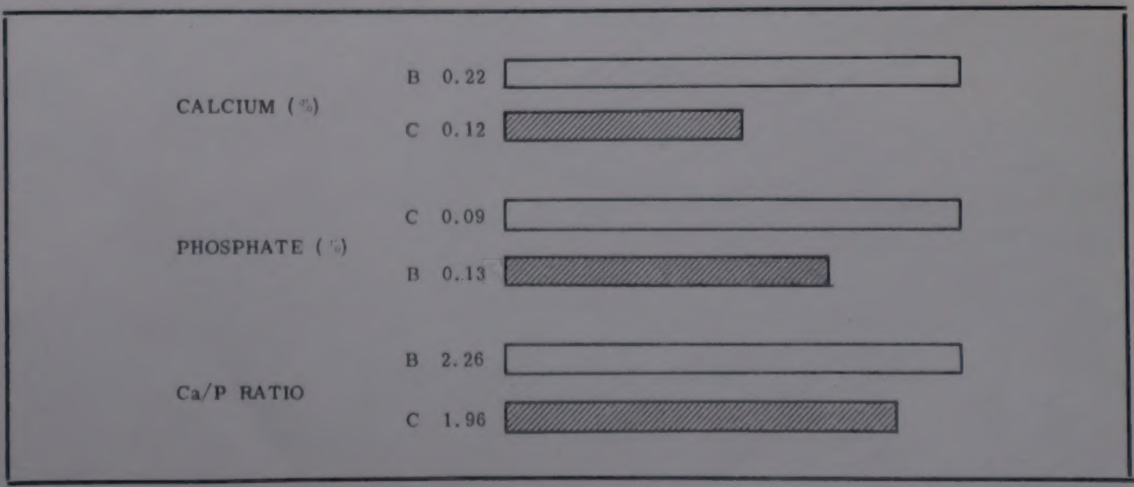


Figure 3 *Mineral composition of buffalo (B) and cow (C) milk*

milk from 15 minutes (untreated sample) to 60 minutes.

Manufacture of products

Egypt and India have made considerable progress in the manufacture of a variety of conventional and indigenous milk products from buffalo milk. Summarized information on the types of products manufactured from buffalo milk is given in Table 3. A decade ago, a number of problems were encountered when cow milk technology was applied to buffalo milk processing (Dalaya and Patel, 1971). This called for a new look at the physico-chemical changes that occur in buffalo milk during heat treatment, rennet treatment and microbial fermentation. As a result, a major breakthrough was made in arriving at suitable modifications to cow milk technology when applied to the manufacture of buffalo milk products. The National Dairy Research Institute (NDRI), in particular, has conducted systematic research into buffalo milk processing (Ganguli, 1978).

Problems encountered with buffalo milk proteins. Adequate data are now available to demonstrate that buffalo milk casein differs from cow milk casein in terms of micellar size, voluminosity (solvation), susceptibility to rennet, compositional heterogeneity and mineral constituents (Ganguli, 1973,

TABLE 3. **Milk products manufactured from buffalo milk**

Name of product	Name of manufacturer	Country	Reference
Cheese			
Domiati	Animal Production Research Institute	Egypt	El-Koussy *et al.* (1974)
Mozzarella	Caseificio Co. VA. L.C., Valtusciano	Italy	
Cheddar	NDRI	India	Srinivasan and Burde (1972)
Karnal (quick ripening)	NDRI	India	Bhattacharya *et al.* (1970)
Brick	NDRI	India	Srinivasan and Burde (1972)
Surati	NDRI	India	Bhattacharya *et al.* (1972)
Cottage	NDRI	India	Bhattacharya *et al.* (1971)
Processed	NDRI	India	Kulkarni *et al.* (1975)
Condensed milk	NDRI	India	Bhanumurthi *et al.* (1971)
	Food Specialities	India	
	Indodan	India	
	AMUL	India	Dalaya and Patel (1971)
Butter	AMUL	India	
	NDRI	India	
Skim and whole milk powder	NDRI	India	
	AMUL	India	
	Organized Sector	India	
	Food Science Department, Cairo	Egypt	Helal *et al.* (1976)
Infant milk food	AMUL	India	
	NDRI	India	
	Food Specialities	India	
	Glaxo	India	
Indigenous milk products			
Khoa	Cottage Industry	India	
Ghee	Cottage Industry	India	
Dahi	Cottage Industry	India	
Channa/Paneer	Cottage Industry	India	

Murrah buffaloes in an Indian village. Some cattle are also visible behind the buffaloes.

1974b). Some specific products are cited below indicating the major problems faced, probable reasons for them and remedial steps.

CHEESE MANUFACTURE. Owing to the difference in the micellar composition of milk casein and the higher levels of calcium and fat in buffalo milk compared with cow milk, the major problems faced in the manufacture of cheddar cheese have been in acidity development, renneting time, retention of moisture and slow proteolysis and lipolysis. By altering the preparation and load of starter culture, rennet concentration, cheddaring period and standardization of casein:fat ratio, it is possible to prepare cheese of good quality from buffalo milk (Ganguli, 1978).

Cheese made from buffalo milk tends to have a hard and dry body and a short and crumbly texture, combined with slow ripening capacity. Buffalo casein micelles, being larger in size, retain less water than do cow casein micelles during curd formation. The voluminosity of the casein micelles from buffalo milk is less than that from cow milk and it rapidly decreases in the temperature range 35-45°C. Hence, it is necessary either to drain the whey earlier than is the case with cow milk or add sodium chloride while cheddaring the cheese cubes to retain more moisture. Dr J. Czulak of Australia has standardized a method of producing cheddar cheese from buffalo milk (Czulak, 1964). In India both the Kaira District Milk Producers' Union (commonly known as AMUL) and the scientists at NDRI have successfully prepared Surati cheese and Karnal cheese from buffalo milk (Bhattacharya *et al.*, 1969, 1970, 1972). The varieties of buffalo milk cheese manufactured today are shown in Table 3. Steps in the manufacture of Karnal and Surati cheese are given in Table 4.

In Italy a typical local cheese prepared from buffalo milk is mozzarella cheese. In a pilot study conducted in Iraq under the auspices of FAO, a method suitable for the manufacture of mozzarella cheese from buffalo milk in that country has been developed. AMUL has also started production of such cheese.

The problems involved in cheese manufacture from buffalo milk have been recently reviewed by Ganguli (1978) from the standpoint of the different physico-chemical properties cited above. The major defects, probable reasons for these and techniques for overcoming them are summarized below.

- *Major defects*
  - — Slow development of acidity;
  - — Faster renneting time than in cow milk;
  - — Low retention of moisture by micelles;
  - — Slow flavour development;
  - — Slower proteolysis and lipolysis than in cow milk.
- *Probable reasons for defects*
  - — High buffer capacity due to high mineral content;

Milk and milk products prepared from buffalo milk at NDRI

Paneer making at NDRI

— High level of Ca^{++} in the micelles;
— Low voluminosity at 35-40°C and large micelle size;
— Slow primary action of rennet and low susceptibility of casein to proteolysis.

- *Modified techniques*
  — Add more starter culture to enhance acidity development;
  — Lower the rennet concentration to prolong the milk clotting time;
  — Reduce the cheddaring period to retain more water in cheese, or use a salting process;
  — Standardize casein:fat ratio to 0.7:1.0 by using cow milk powder to improve ripening process.

TABLE 4. **Steps in the manufacture of Surati and Karnal cheese from buffalo milk**

Steps of production	**Surati cheese**	**Karnal cheese**
Coagulation		
Milk standardized to casein:fat ratio	1 : 0.7	1 : 0.75
Pasteurization of milk	71°C for 5 minutes	75°C for 15 minutes
Preripening	—	10 ml starter/100 l milk to develop 0.02 increase in acidity at 8-18°C
Incubation/inoculation temperature	35-36°C	34-35°C
Addition of $CaCl_2$	—	15 ml (40% $CaCl_2$/100 l)
Addition of starter	0.04%	1.5 × 2%
Addition of rennet	7.5 g/100 l milk	2.5-3.0 g/100 l milk
Processing		
Setting time of curd	30 minutes	30 minutes
Cutting of curd/cooking of curd	—	1.10
Addition of salt	After 5 minutes of cutting, dry salt added (2.5%)	—
Cheddering in whey	—	Till acidity reaches 0.40 to 0.43%
Draining of whey	Drained after 30 minutes of cutting of curd	After 5 to 7 hours
Washing of curd	—	With 2 l water/kg curd at 73°C, 5 minutes
Hooping	Brick cheese hoop without pressure, first turning after 30 minutes, second turning after another 30 minutes	Hooping with cloth 8-12 hours, and without cloth at 37°C
Brining	—	In pasteurized saline (18%) for 15 to 30 days at 15°C
Washing with warm water	—	Alternate days for 7 days
Storage of cheese	Sliced in desired size and steeped in whey and stored at 4-6°C	Paraffining and storage at 15°C

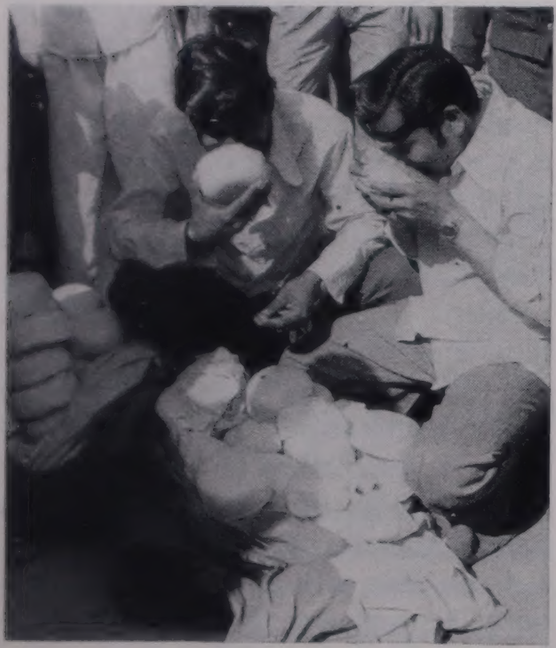
Source: Bhattacharya **et al.** (1970, 1972).

CONDENSED AND EVAPORATED MILK. The manufacture of concentrated milk from buffalo milk poses a number of problems during both manufacture and storage, primarily concerning viscosity, lactose crystallization, age thickening and discoloration of products (Dalaya and Patel, 1971). Solutions to these problems lie in choosing the right preheating temperature, the best time to add sugar, the speed and method of cooling the concentrate, and inducing lactose crystallization under controlled conditions of temperature and agitation. The poor heat-stability of buffalo milk (due to a high concentration of minerals, particularly calcium) and the large micellar size of casein particles are the reasons for gel formation. β-lactoglobulin from buffalo milk is more denatured when heat-treated than is cow β-lactoglobulin (Shazly *et al.*, 1973). An increase in the concentration of this protein leads to increased molecular association in buffalo milk and this facilitates gel formation. The major defects, probable reasons for them and steps used to correct them in the technology of this product are given below.

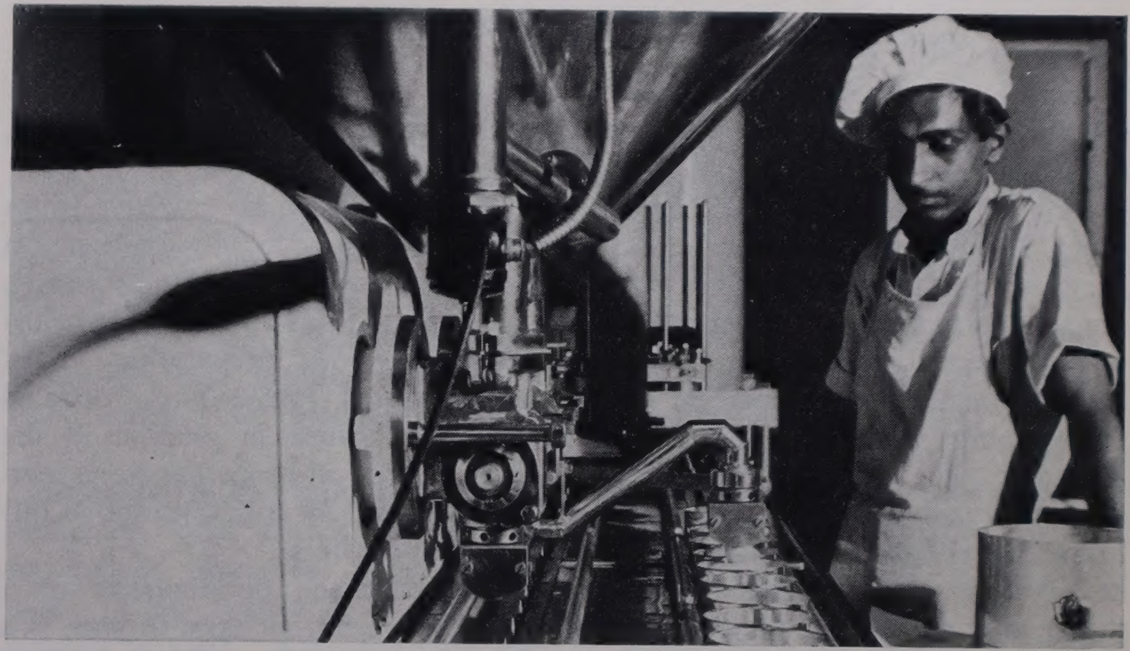
- *Major defects*
  — β-lactoglobulin is vulnerable to heat;
  — Fast gel formation during manufacture;
  — Lactose crystallization;
  — Age thickening;
  — Discoloration.
- *Probable reasons for defects*
  — Fast heat denaturation of β-lactoglobulin;
  — High level of bound Ca^{++} in the casein micelles;
  — Poor heat stability owing to high proportion of calcium in casein;
  — Larger micelles, higher salts and more molecular aggregation of β-lactoglobulin in buffalo milk than in cow milk;
  — Low β-carotene content.
- *Corrective steps*
  — Set the right preheating temperature (115-120°C);
  — Determine the best time to add sugar;
  — Choose the best speed and method of cooling;
  — Induce lactose crystallization under controlled conditions of temperature (30°C for 3 hours);
  — Add sodium citrate as a stabilizer.

A large number of milk-product factories in India now successfully manufacture condensed milk from buffalo milk. Although condensed milk can be prepared successfully, the manufacture of evaporated milk from buffalo milk poses major problems due to coagulation during sterilization and age thickening during storage. The mineral balance in buffalo milk and the properties of buffalo milk proteins (Ganguli, 1974a) are the major factors responsible for its poor heat stability. Re-

Khoa



Testing khoa in an Indian market



Infant food manufactured from buffalo milk at AMUL dairy

cent trials at NDRI have suggested that the addition of acid casein (with low calcium) improves the heat stability of buffalo milk by bringing about a change in the calcium:casein ratio.

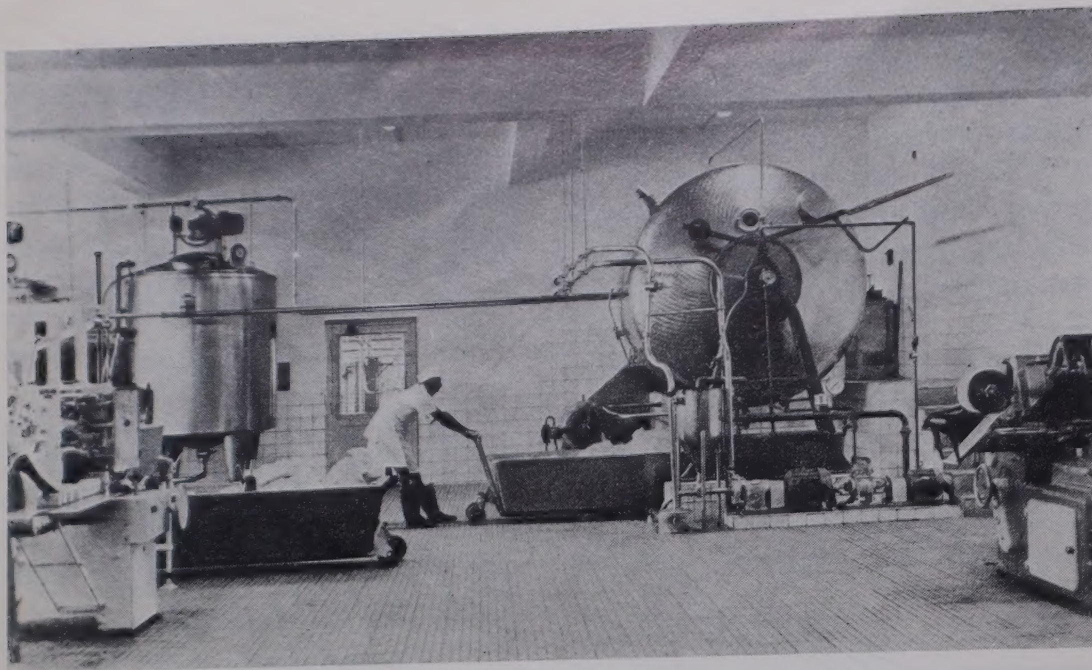
Problems encountered with buffalo milk fat. Milk fat is used in the manufacture of several products such as cream, butter, ghee and cheese. The structural and chemical properties of milk fat greatly influence the melting point, crystallization behaviour, emulsifying property, solubility and surface activity. Ramamurthy (1976) has correlated these properties of milk fat with the technological problems encountered in processing buffalo milk for the manufacture of products based on milk fat.

The problems encountered with milk fat in dairy processing are as follows: crystallization behaviour of fat in the manufacture of butter; breakdown of milk fat during ripening of cheese affecting flavour development; autooxidation of milk fat resulting in off-flavour during storage of milk products; and emulsification of fat in the preparation of processed cheese and ice-cream. The data on the major differences between buffalo milk fat and cow milk fat are available (Ramamurthy and Narayanan, 1974). These are as follows: buffalo milk fat is richer in butyric acid, in long-chain fatty acids like palmitic acid and stearic acid and in some polyunsaturated fatty acids, whereas it is lower in medium-chain fatty acids (from C_6 to C_{12}); summer milk fat contains higher levels of stearic and oleic acids and lower amounts of palmitic, myristic and lower fatty acids; buffalo milk fat has a higher saponification value, Reichert value, Kirchner value and melting point, and has a lower butyrorefractometer index, Polenske value and iodine value. The ways in which these properties of buffalo milk fat are likely to influence product quality are considered below.

BUTTER MANUFACTURE. Buffalo milk fat is distinctly harder than cow milk fat. The reason for this is the presence of large amounts of long-chain saturated fatty acids, such as palmitic and stearic acids. The amount of triglycerides with high melting points is significantly higher in buffalo milk fat. As a result, the triglycerides crystallize much earlier in buffalo than in cow milk fat. The time and temperature required for ageing of cream to reach the optimum condition of fat in cream will be different for buffalo and cow cream.

GHEE AND SAMNA MANUFACTURE. Ghee in India and samna in Egypt are clarified butterfat. A significant quantity of buffalo milk is diverted for the manufacture of these products. Ganguli and Jain (1973) published a detailed review of the chemistry, processing and technology of ghee prepared from both cow and buffalo milk. Ghee from buffalo milk has almost no colour, unlike cow ghee, which looks golden yellow due to the presence of carotenoids.

Ghee has been extensively used from time immemorial both in the diet and in the religious functions of Hindus in India. It is admirably suited for use in tropical conditions and is the only source of animal fat in an otherwise predominantly vegetarian diet in India. About 43 percent of the total milk production in India is utilized in making ghee, with total annual ghee production estimated at 480 million kg, the value of which is approximately $US313 million (rupees 2 500 million). Uttar Pradesh, Punjab and Rajasthan



The production of AMUL butter

are the major ghee-producing States in India. The average annual intake of milk fat as ghee is about 1.2 kg per caput, 80 percent being used for culinary purposes, 18 percent for confectionery purposes and 2 percent for religious ceremonies.

Ghee contains 99-99.5 percent milk fat and not more than 0.5 percent moisture. The unsaponifiable matter in ghee contains vitamin A (15-40 IU/g), tocopherol (18-48 μg/g) and, in the case of cow ghee only, carotene. In addition, ghee contains free fatty acids to the extent of 2.8 percent, traces of charred casein (known as ghee residue) and sometimes salts of copper, iron, etc. Its melting point is 28-44°C; specific gravity 0.93-0.94; refractive index 40-45 at 40°C; Reichert and Meissl value not less than 220; and iodine value 26-38.

Ghee is prepared from either butter or cream and is generally manufactured by two methods: from creamery butter made from mechanically separated and churned cream or from "desi" butter made by churning "dahi" or cream. The latter accounts for the bulk of the ghee produced in India. Clarification is accomplished by heating the butter or cream at 120°C. The actual technique varies from place to place and so also does the yield of ghee vary according to the method of preparation. A continuous ghee-making machine is being constructed at NDRI. The addition of phospholipids can prolong the keeping quality of ghee. Ghee residue, which is rich in phospholipids, can prevent auto-oxidation in ghee. Layer formation in ghee, which brings about differences in physico-chemical properties, can be prevented by storing ghee at a temperature of 20°C or below immediately after preparation. Latif and Mazloum (1969) made detailed studies on samna in relation to the physico-chemical properties of its fractions obtained by crystallization at different temperatures.

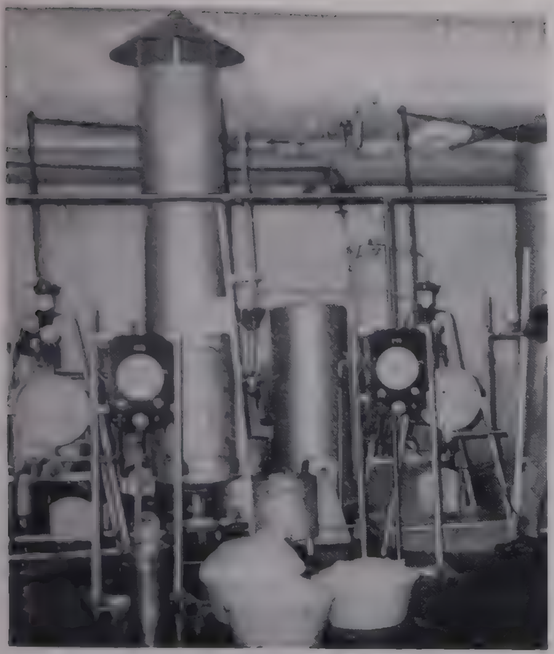
Preventing the development of a rancid or off-flavour taste in ghee is a major problem. The physical state of the milk fat is an important factor that influences the rate of lipolysis. The rate of lipolysis of buffalo milk fat is much slower than that of cow milk fat (Ganguli, 1974a). This might explain why cow ghee is more likely to develop a rancid flavour during storage than is buffalo ghee. Auto-oxidation of milk fat resulting in the development of off-flavours poses a different problem. Buffalo milk fat is more prone to auto-oxidation than is cow milk fat, and hence buffalo ghee has a poorer shelf life than cow ghee. A possible reason for this is the greater amount of highly unsaturated fatty acids in buffalo milk fat than in cow milk fat.

CHEESE RIPENING. During cheese ripening, the release of free fatty acids that contribute to a typical cheese flavour is due to milk-fat lipolysis. Such lipolysis is slower in buffalo milk cheese than in cow milk cheese. Therefore, free fatty acid release is present to a lesser extent in buffalo milk cheese than in cow milk cheese during ripening.

Problems encountered with mineral balance. Buffalo milk is richer in certain minerals than cow milk (Figure 3), particularly in calcium (0.22 percent *v.* 0.12 percent) and phosphorus (0.13 percent *v.* 0.09 percent). The calcium:phosphorus ratio is also higher in buffalo milk (2.26:1) than in cow milk (1.96:1). In general, it is observed that cations (calcium and magnesium) are more numerous in buffalo milk than anions (phosphate and citrate). The soluble forms of calcium, magnesium and citrate are found in small amounts in buffalo milk. As a result of a high calcium content in buffalo milk, the milk exhibits low heat stability, high curd tension and a low rennet coagulating time compared with cow milk. Low heat stability poses problems in condensed milk manufacture; and high curd tension and fast rennet coagulation pose problems in cheese manufacture. The ratio of calcium + magnesium to phosphate + citrate is high in buffalo milk, which further explains its low heat stability. It is possible to improve the heat stability by replacing 25 percent of the bound calcium in buffalo milk by electrometathesis (Balachandran and Srinivasan, 1974).

Milk-based foods

Milk powder and infant milk food. Major success has been achieved in India in the manufacture of milk-based foods and the formulation of infant food from buffalo milk. Chandrasekhara *et al.* (1957) were the first to standardize a method for the manufacture of infant food from buffalo milk. The main steps in the production of such infant food were: reduction of fat content to 2.5 percent; the addition of phosphate buffer salts to trap the ionized calcium and thereby reduce curd tension; the addition of sugar to reduce the proportion of protein and fat; concentration of fluid; the addition of vitamins; homogenization; and drying and packaging under



A continuous ghee-making machine designed at NDRI

The AMUL dairy complex in Anand, Gujarat, India

inert gas. This method was first adopted by AMUL, at present the world's largest producer of buffalo milk infant food.

To obtain the best results for the preparation of milk powder from buffalo milk the following points should be taken into account:

- The solubility index is slightly higher in the case of buffalo milk powder than in cow milk powder;
- The quality of the powder is influenced in the same manner as cow milk powder, by manufacturing conditions including the heating temperature, steam pressure for roller drier, and inlet and outlet temperature of air in spray drying;
- Higher levels of preconcentration give a powder with better solubility;
- Optimum conditions (single pass anhydro process) are: 50 percent total solids concentration, holding temperature of 5°C for 12-14 hours for crystallization of lactose, atomizer speed of 7 000 rev/min, and inlet temperature of 200°C;
- The effect of heat on casein micelles and their degree of clustering in buffalo milk should be recognized.

Humanized buffalo milk. In recent years, scientists at NDRI have tried to modify buffalo milk in such a manner that it simulates human milk. The first attempt at making such a product with buffalo milk was in the author's laboratory (Ganguli, 1976).

Preliminary results are promising. The product is at present under study to determine its shelf life. Infant feeding trials and composition evaluation are also being conducted in collaboration with medical institutes in India and a milk company in Japan.

Fermented milk products. Certain fermented milk products have been successfully prepared from buffalo milk. Dahi (yoghurt) is one such popular product. The high curd tension of dahi from buffalo milk is due to its high calcium content. The development of acidity during fermentation is also slow. The consistency and body of yoghurt are better when prepared with buffalo milk, whereas the flavour score is better with cow milk. With heat-treated milk, the rate of acid production was higher in buffalo milk than in cow milk. Other fermented products like srikhand and lassi have been developed in powder form at NDRI.

"Zabady" is an Egyptian fermented buffalo milk product similar to yoghurt. The predominant organisms found in zabady are *Streptococcus thermophilis, Lactobacillus* sp. resembling. *L. Bulgaricus* and *Saccharomyces fragilis.*

In India, buffalo milk is preferred by those who prepare certain indigenous milk products because of its quality and because consumers also prefer it. According to estimates, about 53 percent of all milk produced in India is converted into indigenous milk products like khoa, a coagulated milk product prepared by partial dehydration of milk, with a moisture content varying between 19 and 25 percent. Buffalo-milk khoa has a characteristic body and textural qualities that consumers prefer to cow-milk khoa. A detailed account of the production and marketing of khoa has recently been published by Arora, Patel and Rajorhia (1976).

Khoa forms the basis of a number of indigenous sweets. About 7 percent of all milk produced in India is utilized for khoa manufacture with an annual production of 320 000 tons worth $US320 million. Uttar Pradesh accounts for 42 percent of the total khoa produced in India.

Paneer is another milk product indigenous to India that is more often prepared from buffalo milk than from cow milk. It comprises acid-coagulated milk solids and is used as an ingredient for cooking with vegetables in northern India. It is similar to cottage cheese prepared by acid coagulation in Europe and North America. Recently a detailed study has been carried out at NDRI to standardize the production of paneer from buffalo milk (Bhattacharya *et al.*, 1971). The best quality product is made from milk with 6.0 percent fat. Paneer can be stored for 6 days at 10°C without much deterioration in quality but the freshness of the product is lost after 3 days.

Conclusions

In some developing countries buffalo milk constitutes a major portion of the milk produced. There is an increasing trend in its utilization for the manufacture of milk products that are otherwise commonly made from cow milk. As a result, there is a continuing need to study the physico-chemical and other properties of buffalo milk to facilitate standardization for processing. In some respects buffalo milk has been found to differ from cow milk in its properties. It was expected therefore that certain problems would arise in the processing of buffalo milk for the manufacture of milk products. Some of these problems and solutions to them have been highlighted in this article.

Buffalo-milk technology has now been standardized in India for the successful manufacture of milk products known throughout the world such as cheese, condensed milk, milk powder, infant milk food, and humanized buffalo milk. In addition, several indigenous buffalo milk products are also manufactured in Bulgaria, Egypt, India and Italy. Ghee, khoa and paneer form the major products in India.

There are still several areas where further research into buffalo milk processing is needed; one such area is the manufacture of evaporated milk. ■

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Milk production in the European Community - its implications for breeding policy

J.L. Jollans

In 1977 the nine countries of the European Community (EC) produced 24.8 percent of the world supply of cows' milk from 12.3 percent of the world's dairy cows. In trade between themselves, these countries also accounted for 60 to 70 percent of the world trade in butter, cheese and milk powders (Milk Marketing Board, 1978). Milk is the most important farm product of the EC, representing 18.5 percent of the value of farm output (EC, 1976), and the dairy herd makes a major contribution to beef supplies in the form of surplus calves and cull cows. Table 1 gives some basic statistics of the individual countries and the whole community.

However, the supply of milk is now well in excess of consumption, and considerable sums are being spent annually by the Community to support prices to farmers while disposing of surpluses at a loss. Indeed this support was expected to cost $176 per dairy cow in 1978, representing by far the largest item of expenditure in the Community budget. Owing to the high prices and the subsidies, production is still being stimulated and fairly drastic measures will be needed to bring production back into line with consumption without causing social problems among farmers and farm workers that would be costly to solve.

Although from certain viewpoints, such as yield of milk per cow, it can be argued that EC milk production is efficient, there are doubts as to what constitutes efficiency and as to whether the dairy industry is being properly assessed. The Centre for Agricultural Strategy (CAS) recently published a study of the dairy industry of the United Kingdom (UK) with far-reaching proposals for reform (CAS, 1978). This study is the basis for the present article since many of its recommendations seem applicable to the EC as a whole, and the methods of appraisal used may be of value to those concerned with development plans in other countries. The subject has many aspects and some discussion of each is needed for a full appreciation of future needs and opportunities.

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Milk and milk products. Milk contains many nutrients in variable amounts, the most important in quantitative and economic terms being fat, protein, and lactose. The fat is nearly all of the saturated type, due partly to formation from carbohydrates and partly to the saturation of feed oils in the rumen. Of the protein, 75 percent is coagulable casein and 25 percent other, non-coagulable, proteins. The average composition is about 3.8 percent fat, 3.2 percent protein, and 4.6 percent lactose, the fat being the most variable, then the protein, and lactose the least. With modern technology it is possible to separate these components in the dairy and recombine them in any desired ratio. This facility underlies the concept of farm milk as a raw material for the dairy trade that CAS is now proposing.

Milk may be sold for the liquid market in its natural composition or with part or all of the fat removed. Currently, about 80 percent is in its natural form or standardized to approximately that level, but this percentage is slowly declining from a level of 96 percent in 1970.

Alternatively, the milk may be processed to form cream and butter (from the fat) leaving skimmed milk (the protein and lactose) as a by-product, or processed to form cheese (from the fat and casein) leaving whey (the non-coagulable proteins and lactose) as a

TABLE 1. **EC dairy cow statistics**

Country	No. of dairy cows (× 10³)	1975 average herd size (Cows)	Average yield (Kg per cow)	Average fat content of milk (Percent)	Utilization of milk by dairies (Percent): Liquid sales	Cream and butter	Cheese	Other
Germany, Fed. Rep.	5 417	9.4	4 181	3.82	11	66	12	11
France	7 512	12.0	3 297	3.76	10	56	28	6
Italy	2 945	5.4	3 245	3.48	24	24	50	2
Netherlands	2 212	24.2	4 815	3.97	7	41	29	23
Belgium	974	13.3	3 690	3.43	20	60	6	14
Luxembourg	68	16.6	3 658	3.79	12	87	—	1
United Kingdom	3 327	40.0	4 621	3.78	52	29	13	6
Denmark	1 087	16.3	4 690	4.22	7	57	23	13
Eire	1 484	10.4	2 977	3.53	10	66	14	10
Total EC	25 026	11.3	3 851	3.78	18	50	22	10

Source: Milk Marketing Board (1978).

by-product. There is also a variety of ways in which water is removed from the milk to give evaporated, condensed or dry powder forms.

The by-products, — skimmed milk from butter production and whey from cheese production — generally have very low market values and research over many years has failed to find outlets for them that will pay the full production cost. Post-war prophecies that a substantial world market for skimmed-milk powder would develop are not being realized.

It is important to note that the lactose only finds a lucrative outlet as part of whole milk, that the protein is largely restricted to liquid milk and cheese, but that the fat is present in all main products. The limit to the requirements for milk from farms is really the limit to the requirements for milk fat, since the protein and lactose are in surplus much before the fat causes any surplus problems.

Figures 1 and 2 show how consumption of the main dairy products has varied in the UK over the past 25 years and what such variation has meant in terms of proportions of fat, protein, and lactose. The composition of consumption has consistently been different from the average composition of milk produced on farms.

In the EC as a whole the deviation of composition of consumption from supply of milk components is even more marked owing largely to the lower consumption of liquid milk, and therefore of lactose and protein (see Table 2).

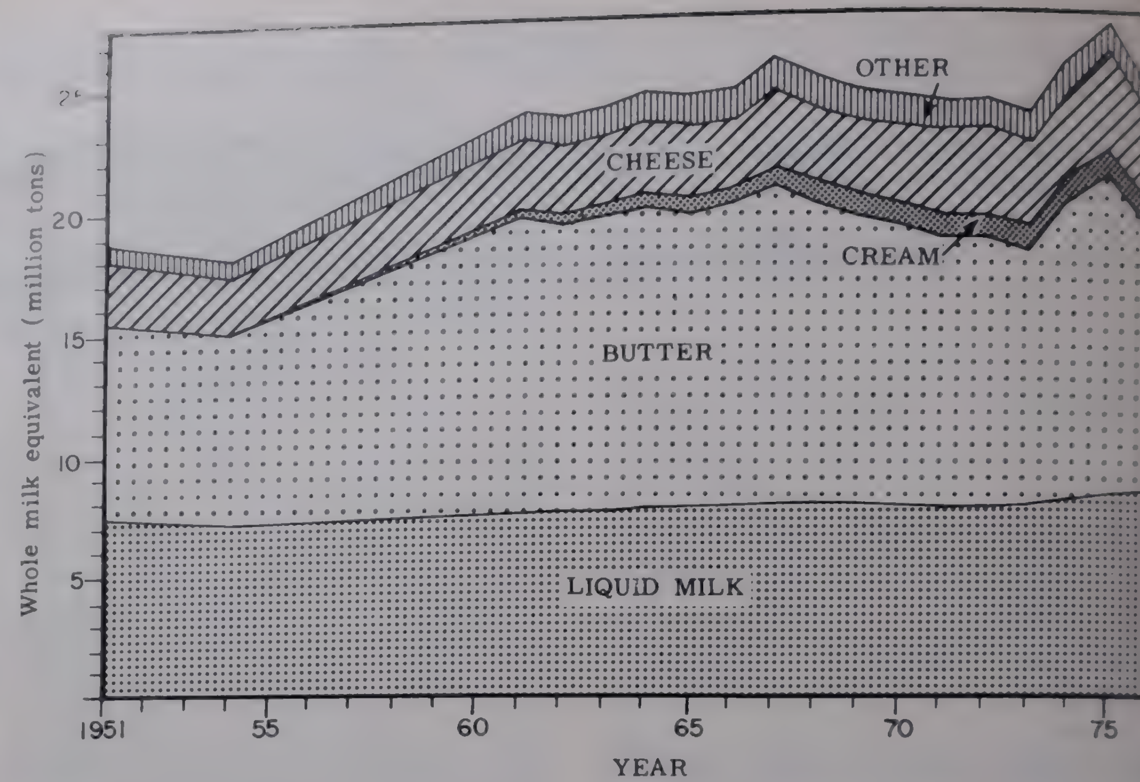


Figure 1 *The whole milk equivalent of the United Kingdom consumption of dairy products (1951 to 1976).*

TABLE 2. **Demand for milk components in main dairy products**
(Thousand tons)

	Weights of components per year			Component ratio		
	Fat	Protein	Lactose	Fat	Protein	Lactose
EC	2 962	1 388	1 038	2.85	1.34	1.00
Of which:						
EC less UK	2 124	1 023	637	3.33	1.61	1.00
UK alone	839	365	401	2.09	0.91	1.00
Present average milk[1]	3 281	2 830	4 036	0.82	0.70	1.00

NOTE: These figures show the extreme position in that they do not allow for any unavoidable by-products. The figures are derived from average demand for dairy products over a 3-year period — either 1973/74/75 or 1974/75/76, depending on the availability of data.

[1] Estimates of the weights of milk components produced in the EC in 1977 for delivery to dairies.

TABLE 3. **The contribution of foods and their fats to household dietary energy**
(Percentage)

Food or food group	Whole food	Fat	Fatty acids: Saturated	Mono-unsaturated	Polyunsaturated
Liquid milk	11.5	5.84	3.63	1.78	0.15
Other milk and cream	1.2	0.58	0.35	0.19	0.07
Butter	7.3	7.15	4.45	2.13	0.19
Cheese	2.5	1.86	1.16	0.54	0.04
Total, dairy products	22.5	15.43	9.59	4.64	0.45
Other fats — including margarine	7.8	7.66	2.78	3.25	1.31
Meat	16.0	11.25	4.83	4.95	0.97
Cereals	30.0	3.98	1.86	1.31	0.62
Eggs	1.9	1.24	0.46	0.58	0.19
Other foods	1.6	0.58	0.15	0.23	0.15
Vegetables	7.3	0.50	0.15	0.19	0.12
Fish	1.0	0.43	0.12	0.15	0.15
Fruit	2.5	0.19	0.08	0.08	0.04
Beverages	0.4	0.04	0.04	0.01	0.01
Sugar and preserves	9.1	—	—	—	—
Total, others	77.5	25.87	10.47	10.75	3.56
TOTAL	100	41.30	20.06	15.39	4.01

Source: Calculated from Ministry of Agriculture, Fisheries and Food, 1975.

Milk and human health. Future consumption of milk and milk products may be influenced by medical considerations. There was a time when milk was ascribed almost mystical nutritional properties and medical commendation certainly helped sales and influenced government policy toward dairy farmers. That era is now over and, though most doctors still regard milk as a valuable food for many people, there are qualifications.

The consumption of fat, above a certain level, has been associated with other risk factors in the aetiology of atherosclerosis and coronary heart dis-

ease (Royal College of Physicians, 1976); where consumption exceeds this level (variously set at 30 or 35 percent of dietary energy) there is now strong medical pressure to reduce the intake of fat, particularly saturated fat. Since (as Table 3 shows for the UK) a high proportion of dietary fat comes from milk and milk products, the recommendations almost automatically include reduction of butter consumption and removal of some fat from liquid milk. It must be stressed, however, that reduction does not imply abandonment, and an overall reduction of 26 percent of dietary fat, shared between all sources, has been suggested (Robbins, 1978).

Some people are allergic to the proteins of cows' milk and may be advised to cease including it in their diets or to use milk from another species (Manson, 1975). A small percentage of Caucasians, but high percentages of Asians and Africans, are allergic to lactose as their output of the digestive enzyme lactase is inadequate (Rosensweig, 1969).

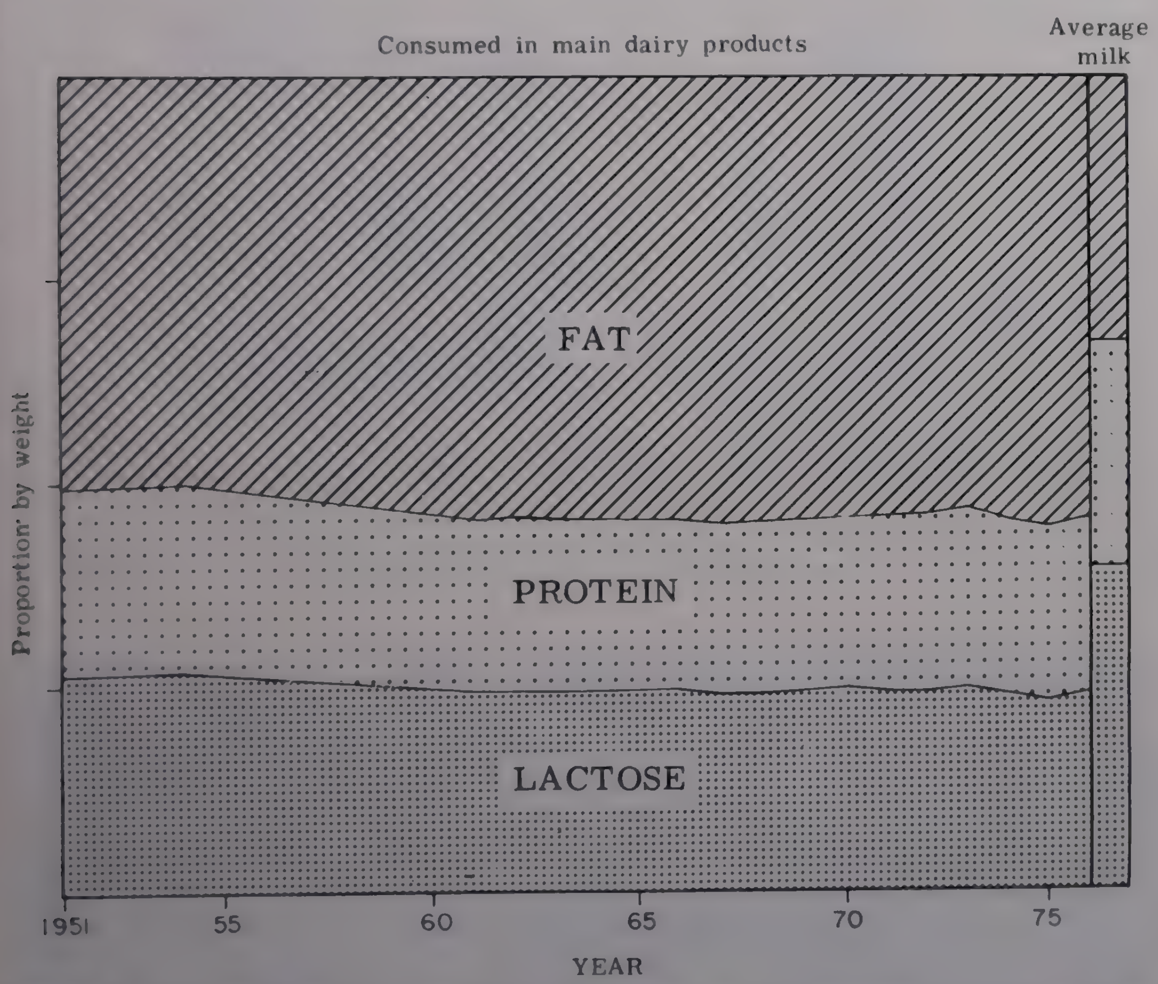


Figure 2 *The proportions of milk fat, protein, and lactose consumed in the main dairy products in the UK (1951 to 1976).*

For future dairy-product demand in the EC, only the fat is of major consequence but lactose intolerance may limit the opportunity for sales of skimmed milk powder in Asia or Africa.

Future levels of consumption. To justify any major changes in the industry, a reasoned assessment of future long-term consumption is advisable. Table 4 shows present levels of consumption and their trends; it is, however, considered that extrapolation for more than a few years ahead is unreliable. Figure 2 is possibly more useful as a guide because the ratio of consumption of components is shown to be remarkably constant. For the EC as a whole, one of the noteworthy features is a large fall in the sale of liquid milk and therefore of lactose. Increased cheese consumption has partly compensated for the protein loss.

In the UK, however, the volume of sales of liquid milk has largely been sustained — a success for the dairy industry that is attributed to the retention of the household delivery system and to regular advertising.

CAS approached the problem of future consumption by considering a range of alternatives and then looking for common factors. Liquid milk consumption was assumed to stay constant, allowed to fall by 20 percent, and changed to a semi-skimmed type containing 2.5 percent fat. Butter consumption was considered at 20, 60, and 100 percent of present consumption and cheese at 70, 100, 130 and 160 percent of present consumption. In all, these make 36 possible combinations of total consumption, and the consequences for the fat:protein:lactose ratio were calculated in each case. In comparison with changes over the past 25 years, these combinations cover a much greater range and they also allow for much greater reduction in milk fat consumption than the medical profession is advocating. It is thus assumed that deviations outside this range are very unlikely.

The component ratio was found to vary from 2.30:1.01:1.00 to 0 86:0.80: 1.00 (compared with the present average milk ratio of 0.82:0.70:1.00). The lowest level of fat occurs when all milk is sold as semi-skimmed, butter consumption falls to 20 percent, and cheese to 70 percent. Only in that extreme case would present milk approximate in composition to market consumption. Otherwise the indications all point to a higher ratio of fat to lactose.

This assessment is for the UK. As Table 2 shows, however, the component ratio for the EC as a whole now has a higher proportion of fat and it would require even greater changes than those postulated for the UK to bring the consumption of components into line with their ratio in present average milk.

It seems unnecessary, at this stage, to be more precise. The indications all point to a future consumption-component ratio with more fat than that of present average milk.

Valuing the milk components. Milk is purchased from farmers in the UK on the basis of weight of total solids, which values all components at the

same rate, and by a variety of methods in other EC countries, some of which pay a premium for the fat. These values partially reflect the subsidies that are obtainable for the protein and lactose that becomes skimmed-milk powder, the intervention price of which was $1 240 per ton by the autumn of 1978. However, only a small proportion of liquid skimmed milk and skimmed-milk powder can be sold at such a price on the open market. The rest is sold at a considerable loss largely for animal feeding.

For animal feed, the skimmed-milk powder must compete with such concentrates as extracted soybean meal (about $260 per ton). Lactose alone is of no greater value for human food than sucrose (cane and beet sugar), currently about $500 per ton, and the protein would have to command $2 600 per ton to cover the residual part of the intervention price. This protein is mainly in competition with much cheaper vegetable sources such as the soybean.

Clearly, the present methods of purchasing milk do not reflect the market values of the milk components. Subsidies on the by-products remove all incentive to change milk composition to suit consumption, and therefore merely serve to perpetuate an expensive problem.

The problems of surplus. The present surplus of milk components in the EC has two aspects: an overall surplus of whole milk due to stimulation of supply by over-high prices and subsidies; and, even when the supply of whole milk matches fat consumption, there is a large surplus of protein and lactose for which no profitable market is now available, nor is there any reasonable chance of its developing in the foreseeable future.

These two problems have the same origin, which is overproduction, but the practical answers to them are somewhat different. CAS (1978) suggests that the first problem will only respond to a simple reduction in price for whole milk until supply matches consumption. The EC has too many dairy cows and, as milk yields are continually increasing, the number of cows will have to be reduced.

The European Commission has already recognized the excess-cow problem but its action has been ineffective.

For the second problem, CAS suggests that production of protein and lactose should be reduced while output of fat is maintained; i.e., that the composition of milk should be changed until its average component-ratio corresponds with that required for profitable marketing. Apart from the restructuring of milk-purchasing policy, the subject is largely one for the animal breeders and it is to them that the rest of this article is directed. After such restructuring it would be the task

TABLE 4. **Consumption of milk and milk products in EC countries, 1976 and changes in consumption between 1965 and 1976** [1]

(Kilograms per head per year)

Country	Whole milk	Skim and semi-skim milk	Cheese	Butter	Cream	Condensed milk	Yoghurt	Overall ranking
Germany, Fed. Rep.	52.5 (—36)	22.4	12.3 (54)	6.4 (—25)	4.0 (54)	6.8 (—18)	5.3	7
France	75.3 (—5)		16.2 (36)	9.4 (7)	1.3 (86)	2.0 (25)	7.9	4
Italy	[2] 53.4 (—15)	[2] 14.8	12.5 (45)	2.3 (21)	[2] 0.6 na	na na	na	9
Netherlands	68.7 (—43)	24.7	10.9 (35)	2.5 (—43)	2.1 (24)	10.2 (0)	14.7	5
Belgium	58.0 (—33)	13.0	11.5 (60)	11.2 (30)	1.2 (140)	3.5 (13)	3.8	6
Luxembourg	86.0 (—12)	—	[3] 8.1 (29)	7.4 (—26)	6.3 (54)	1.0 (—52)	6.2	8
Denmark	80.1 (—39)	37.8	[3] 9.0 (1)	7.7 (—24)	6.5 (—6)	na na	13.4	2
Eire	199.3 (—8)	—	2.9 (61)	11.9 (—21)	1.1 (37)	0.5 na	1.4	1
United Kingdom	144.2 (—2)	—	[3] 6.1 (33)	7.6 (—14)	1.5 (50)	2.9 (—15)	1.7	3

Source: Milk Marketing Board (1978).

NOTES: na = not available; — = negligible.
Overall ranking is based on consumption of milk solids.
[1] Percentage change between 1965 and 1976 (where available) is shown in brackets beneath the consumption figure. — [2] Figures for 1974. — [3] Consumption fell between 1975 and 1976.

Jersey cow (Photo: Jersey Cattle Society, UK)

of the dairy trade, using processes already available, to separate the components of the milk between the required dairy products so that the absolute minimum of low value by-product results. Figure 3 compares the present and suggested ways of supplying the UK market.

The problem for animal breeders. The ideal cow for the future will:

- Produce a high yield of milk with no more lactose and protein but a much higher percentage of fat — probably above 6 percent;
- Have a high voluntary feed intake so that it can obtain its required nutrients from the maximum percentage of fodders (since feed nutrients in concentrates cost about twice those in fodders);
- Have a good constitution, legs and udder.

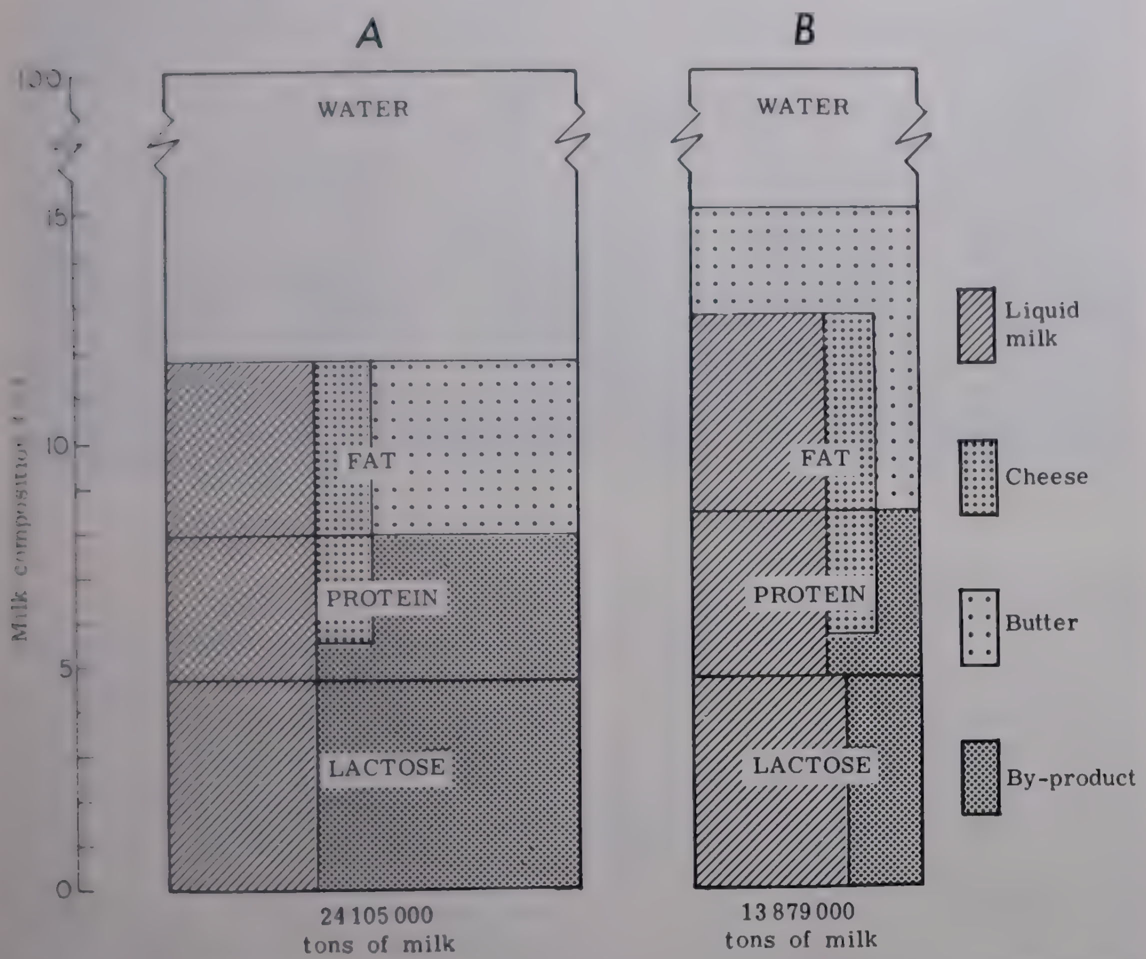


Figure 3 *Two ways of providing the main dairy products for the UK market (A = The present method, including imports; B = The proposed method). The widths of the columns are drawn to scale for the quantities of milk produced.*

A British Friesian cow (Photo: British Friesian Cattle Society)

All calves surplus to herd-replacement needs should be suitable for beef production but this requirement is not of sufficient economic importance to override the need to change the milk composition; beef production needs are also changing.

Added to these qualities, the whole breed system must be flexible enough to permit adjustment to medium-term fluctuations in the demand for milk components.

Do we already possess such an ideal cow? Thoughts of high-fat milk inevitably suggest the Jersey and Guernsey breeds — the Danish Jersey already averages 6 percent fat. Furthermore, the UK Jersey appears to be physiologically capable of more efficient milk production than the Friesian or Ayrshire (CAS, 1978). The problem with the Jersey is said to lie in the use of its calves for beef production and this problem may turn out to be one of ignorance as much as fact. While it seems probable that a cross with the Limousin or Charolais will give an acceptable beef calf, it is not possible to arrange for all calves to be crossbred. Herd replacements will be needed and that means producing a large amount of surplus purebred Jersey males. Whether or not these males are suitable for beef production remains to be determined.

An alternative would be to select for high-fat milk within those dairy breeds whose purebred calves are known to be suitable for beef production, Friesian, Simmental, Meuse-Rhine-IJssel, Danish Red and others. Table 5 gives a list of heritabilities that indicate the opportunities for selection, and genetic correlations that show that some concurrent pressure against an increase in protein percentage would be needed. Calculations based on data from the UK progeny-testing system (Milk Marketing Board, Scottish Milk Marketing Board, and British Friesian Cattle Society, 1977) suggest that prog-

ress would be slow and that average fat levels of about 5 percent might not be achieved for about 20 years.

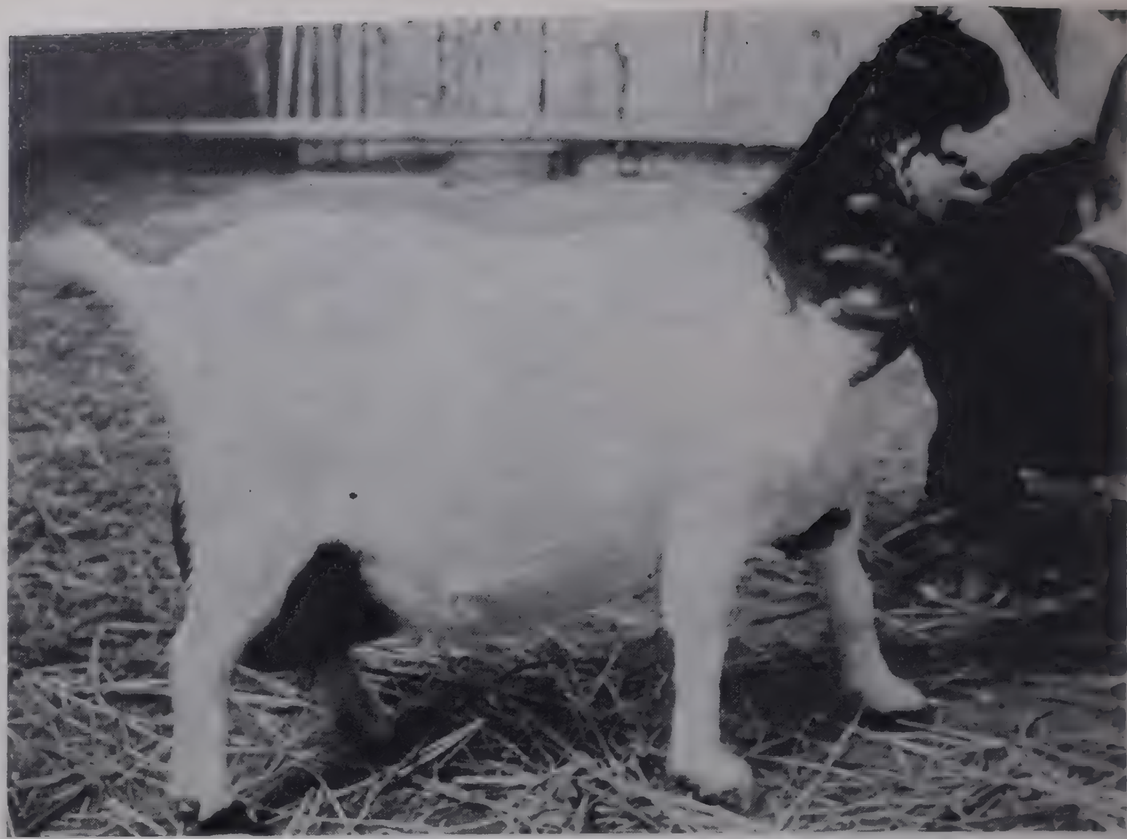
The absence of genetic information on lactose is noteworthy. While the opportunity for increasing fat and protein levels has been studied in many countries, that for increasing or decreasing lactose has not been studied nor has the possible effect on lactose of selecting for the other components. However, there is some indication that lactose is associated with overall yield owing to its effect on osmotic pressure in the alveoli of the udder and therefore that selection for a low lactose percentage could have undesirable consequences. More information is needed on this important subject.

Some programmes have adopted total yield of fat, rather than fat percentage, as the criterion for selection. This approach will not suffice for the present purpose as it takes no account of the inefficiency involved in the use of feed for extra protein or solids-not-fat production. The essential need is for a high yield of milk solids of the right component ratio.

Voluntary feed intake (VFI) has not yet been studied adequately enough to enable it to be properly incorporated in a selection programme. However, it is known that VFI is related to fodder composition, that there is considerable variation between cows and that this variation has a heritable component (estimated at 0.35 to 0.76). Limitation to VFI must be associated, in some way, with the rumeno-reticulo-omasum complex, for the rest of the animal body is capable of processing all the nutrients required for high milk yields.

So far, only purebred cattle have been considered for milk production. Crossbreeding may offer a better solution for the commercial milk producer, however. There are three possible advantages:

- Milk production is more economical and fertility levels are improved. Milk component percentages tend to be averages of those of the purebreds. Thus, if milk containing 6 percent of fat is required it might be obtained from a cross between a Jersey yielding 7.5 percent and a Friesian yielding 4.5 percent. Yield of total milk solids tends to be as high in the cross as in the Friesian but with a lower body weight to maintain (Donald, Gibson and Russell, 1977).
- Deficiencies in beefing characteristics may be overcome.
- A flexible crossing system would offer the opportunity for mid-term variations in milk composition to suit fluctuations in consumption.



A West African dwarf (liveweight at 16 kg)

Conclusions. Though a possible long-term technical solution to the current milk problems of the EC has been suggested, nothing will happen while subsidies distort market demand. Farmers are responding to methods of payment that do not reflect market requirements. They cannot be expected to change until there are appropriate changes to the prices they receive for milk components. However, those concerned with animal breeding should appreciate that they hold the technical key to a long-term solution and that a thorough consideration of the practical consequences for

TABLE 5. **Estimates of heritabilities and genetic correlations** [1]

Heritabilities

Character	*Heritability*[2] ± *standard error*
Milk yield	0.25 ± 0.001
Fat yield	0.23 ± 0.001
Protein yield	0.28 ± 0.011
Fat percentage	0.47 ± 0.002
Protein percentage	0.44 ± 0.010

Genetic correlations [1]

	Milk yield	*Fat yield*	*Protein yield*	*Fat percentage*
Fat yield	0.81 (± 0.035)			
Protein yield	0.85 (± 0.035)	0.85 (± 0.030)		
Fat percentage	—0.31 (± 0.045)	0.21 (± 0.039)	0.08 (± 0.037)	
Protein percentage	—0.28 (± 0.085)	0.14 (± 0.068)	0.23 (± 0.070)	0.58 (± 0.055)

Source: Maijala and Hanna (1974).

[1] The correlation coefficients are weighted means. The standard errors are bracketed as they apply to unweighted means.

Rear view of a West African dwarf doe (Photo: J.L. Jollans)

animal-breeding plans would be appropriate now.

The final question is whether the matters discussed in this article have any relevance to developing countries. Certainly they have but only in their basic principle, not in the practical applications shown for the European Community.

Clearly there is a need for any country with only a small dairy industry, or even no milk production at all, to seriously question whether milk is a necessary product for human welfare. It is not the wonder food people used to consider it and, though very useful in many diets, all its main components have potential disadvantages.

Furthermore, just because the cow is the main animal that has been developed for milk production in Europe, that does not make it the most appropriate for all circumstances in all countries. A dwarf goat giving just enough milk for one child may be more appropriate in both economic and hygienic terms.

In the EC we have learned by painful experience that inappropriate financial support can all too easily lead to undesirable results. Support for by-products that nobody wants will lead to their continued production instead of to measures that might reduce output. Too high a price for a product will eventually lead to too much being produced and correction of the error will be very unpopular.

Perhaps the most important deduction to come from the CAS study was not that the EC needs milk with a different component-ratio but that agriculturists should not take decisions in isolation. Farmers produce food, manufacturers process it and consumers prepare it, so that those who eat it will remain strong and healthy. All those concerned with the processing of foods, with human nutrition and health have ideas that may be of importance to the original food producer, the farmer. This principle holds true for all concerned in the process, since the food producer and processor have information of value to the doctors who wish to recommend dietary changes.

The consequences of collective discussion can be surprising, as in the particular case described here where, though the doctors are recommending a reduction in the amount of milk fat *consumed*, on balance there is sufficient evidence to recommend an increase in milk fat *percentage* at the production level for the EC market. That evidence comes from studies of the history of consumption patterns, the composition of milk and milk products, the genetic components of compositional variance and the latest technology for component separation. It is strengthened by consideration of the costs involved in component production and the subsidies needed to support present methods. Of major interest is the fact that the optimal trends of future consumption all went in the same direction.

The CAS study started as a wide-ranging inquiry into milk in the UK. It was no more than that and there were certainly no initial thoughts of changing conventional selection aims. The resulting conclusions, with their major consequences for dairy cow breeding, were entirely unexpected and quite contrary to prevailing opinion among those immediately concerned, who favoured selection for more milk protein. Furthermore, the breeding aims developed as a logical part of an overall package of recommendations covering the whole dairy industry of the UK. If there is a lesson to be learned it is that to restrict inquiry to a determination of those characteristics that appear to justify improvement by selection is one-sided: it presupposes that there is a need for selection. The problems of an industry should be assessed in depth before any conclusions are drawn as to which disciplines should be involved in a development programme. There may, or may not, be a place for the animal breeder. ■

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Control of contagious bovine pleuropneumonia

with special reference to the Central African Empire

E.P. Lindley

Contagious bovine pleuropneumonia (CBPP) is a serious disease of cattle that still exists in many African territories. If not controlled it may assume epizootic proportions and jeopardize livestock development.

To formulate a country CBPP control programme and to ensure continuity it is necessary to pitch the level of intervention and the measures to be adopted in accordance with the level of development of the livestock industry and the animal health services in the country concerned.

In the past too much weight has been given to technical considerations and not enough to encouraging the social acceptance of CBPP control measures, with the result that all too frequently regression has followed temporary success.

In the Central African Empire, an FAO/UNDP vaccination campaign involving the full collaboration of the cattle owners rapidly reduced the incidence of the epizootic to the extent that in the subsequent 2 years no outbreak of CBPP was reported.

Cattle-crushes are essential to obtain complete vaccination coverage and also facilitate correct inoculation techniques. They may be made of rough-hewn wood, as in the photograph in which the author with project staff is investigating a herd with post-vaccinal lesions.

The cattle industry of the Central African Empire. Most of the 850 000 cattle of the Central African Empire are zebu; these are in herds belonging to the Mbororo who are part of the Fulani ethnic group. About 650 000 zebu are found in the northwestern part of the country (112 000 km^2); their seasonal transhumant movements involve travelling 100-300 km to other grazing areas in the dry season and returning to three designated cattle-raising zones in the wet season. There is also a small influx of Mbororos from Cameroon and Chad into the Central African Empire which varies from year to year. Recently there has been a marked move away from traditional cattle-raising areas owing in part to the degradation of grazing; it is difficult to decide if this change is permanent and whether the movement will continue.

The cattle are mainly of the breed called "Mbororos" but there is a proportion of Fulani zebu cattle (Goudali type). Some of the latter are in the hands of "Foulbé" rather than Mbororo owners: these people tend to settle and are an important element in the commerce of the country.

There are some 15 000 humpless cattle of the Baouli and N'dama breeds in village herds (*métayers*); these were established before 1970, using animals especially imported because of their resistance to trypanosomiasis.

About 1 000 pair of work oxen are localized in particular zones, for example, intensive cotton-growing areas.

As far as supply of meat is concerned, the Central African Empire is a deficit country and most of the cattle

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slaughtered at Bangui, the capital, are imported. There is thus an urgent need to improve animal production and increase the size of the national herd.

CBPP in the Central African Republic. CBPP was reported in the northwest of the Central African Republic in 1958; it probably orginated in Cameroon or Chad. The disease was kept under reasonable control until 1970 when government measures involving agricultural reform terminated technical assistance activities and created a vacuum in animal health control. CBPP became widespread and serious outbreaks occurred.


The sterilization of syringes and needles is essential and here a class of refresher-course veterinary assistants are carrying out the procedure is a cooking pan.

An appeal was made to FAO, which provided 100 000 doses of vaccine and sent a veterinarian to examine and report on the situation. The report produced indicated that the situation was serious and that the whole cattle population in the zone (three quarters of the cattle of the country) was at risk. It was noted that a recrudescence of the disease on the scale indicated posed a serious threat to cattle in neighbouring territories of Chad and Cameroon, because frontier control was inadequate to prevent movement across the boundaries.

As a result of the mission a request was made to UNDP for further assistance. A major control operation started in January 1973. Essential items of equipment (e.g., vehicles and deep freezers) were already on site. Three annual vaccination campaigns were carried out during 1973-75, using 15 mobile vaccination teams. Most of the work was done during the periods June-November when the herds were settled in their wet season grazing. A reduced dry season vaccination campaign was carried out in a zone considered to be enzootically infected.

It was impractical to estimate what proportion of the cattle population had been vaccinated. The Mbororos were particularly anxious to have the vaccination and it was around the periphery of the zone of operations (i.e., to the south and the east), where the cattle population was very dispersed, that logistic difficulties prevented complete vaccination coverage. The numbers vaccinated are shown in Table 1.

The campaign was astonishingly effective, so much so that since March 1976 no outbreak of CBPP has been reported in the western zone. It will not be possible to assume that the disease has been eradicated for several more years but the compaign must be considered as having been successful.

At no time did the project staff use the term "eradication" as among the likely results of the project. It seemed that logistic difficulties precluded this. It was assumed that such a widespread prophylactic immunization would at most reduce the incidence (and therefore the cost) to controllable proportions. The results have thus been much more favourable than expected.

No systematic CBPP vaccination has been carried out since June 1976 but stocks of vaccine have been kept in readiness.

At no time during the years of the campaign was there any evidence of the disease being introduced from neighbouring countries although it was originally considered that such introductions could be a major hazard. Reintroduction cannot be completely precluded for the future.

Provision was also made for scholarships for specialist training overseas for two Veterinary Officers (in addition to the two places on the DANIDA/OAU/FAO CBPP training course held in Ndjamena in April 1973) and for local refresher courses.

TABLE 1. **CBPP vaccination campaign in the Central African Empire**
(Number of animals vaccinated)

Rural commune	1973	1974	1975
Goudrot	99 811	104 265	116 216
Niem	185 027	167 556	140 739
Koui	160 687	114 633	131 429
Other	107 138	143 477	204 241
Total	552 663	529 931	592 625

Control of CBPP in African countries. CBPP is still enzootic in many African states south of the Sahara and in some Asian countries (Table 2); however, the number of outbreaks overall has been considerably reduced in recent years and the present distribution is restricted principally to the less developed areas.

CBPP remains a considerable threat to the cattle population, because if control measures are relaxed, the disease may once more rapidly assume serious proportions, causing great losses especially in areas where animal production methods have in recent years become more intensive.

It is unlikely that funds will be made available to finance the kind of major control campaigns that have been waged in the past.

When speaking of potential rather than actual losses, it is difficult to convince administrators of the necessity to sustain the fight against this disease. Ministries and departments responsible for animal health should be encouraged to accept the need for and the cost of constant vigilance, and incorporate into their routine budgets adequate provision for control measures necessary for the eventual eradication of the disease (Lindley, 1973).

Development aid for animal health is now best directed to improving the general efficiency of veterinary services rather than to mounting exclusive, massive and expensive campaigns against CBPP (or indeed any other animal disease). The immediate aim is to ensure that local services maintain constant surveillance and have the functional capacity to contain disease wherever it is found, thus keeping losses to a minimum and preventing the spread of the disease to other areas or neighbouring territories.

Several factors concerning CBPP need to be appreciated in order to apply successful control measures: the infection is for all practical purposes restricted to the bovine; it is not infective for man and the meat from carcasses of slaughtered sick animals is fit for human consumption (unless condemned for other reasons); the microorganisms are spread between cattle in the expired breath of an infected animal and not by any other means (Hudson, 1971).

The post-vaccinal lesion may occur 2-4 weeks after inoculation and cattle owners have to be warned of this possibility. They should seek advice from the vaccinating team who must be equipped with medical supplies to treat the swellings. It is better to treat these lesions when they are small and not allow them to become as big as the one illustrated.

Slaughter policies. The compulsory slaughter of cattle, especially cattle belonging to nomadic peoples, is a harsh intervention extremely unpopular among owners. It must not be undertaken without providing owners with adequate compensation. Slaughter policies are almost impossible to apply effectively under present conditions in Africa. Indeed, one need not have recourse to the old draconian measures, for veterinary services may now logically assume a more long-term attitude to CBPP, there being widespread confidence that when located it may be reduced successfully and that its lingering presence need not militate against the introduction of intensive methods of animal production or animal industry, e.g., cattle fattening, work with oxen, or dairy farming.

As there have been no major changes in control of cattle movements or any great improvements in local animal health services, one may well ask how this confidence with respect to CBPP control has come about. Undoubtedly the most important factor is the availability of the dried vaccine based on the *Mycoplasma mycoides* Strain T1/44 which is both effective and stable.

TABLE 2. **Incidence of contagious bovine pleuropneumonia**

Country	Status
Mauritania	d
Sudan	c
Ethiopia	g
Djibouti	a
Somalia	d
Kenya	f, g
Rwanda	a
Chad	d
Niger	f, g
Upper Volta	d
Mali	e
Senegal	c
Guinea	c
Sierra Leone	c
Ivory Coast	e
Ghana	g
Togo	g
Benin	g
Nigeria	d, g
Cameroon	g
Central African Empire	e, g
South Africa	b, g
Angola	e
El Salvador	a
Iraq	a
Bahrain	b
Kuwait	c
India	g
Nepal	c
Bhutan	c
Burma	c
China	g
Mongolia	d

Source: Animal Health Yearbook. FAO/WHO/OIE. 1977.

NOTE: Countries not on the list have no record of the disease: a = Suspected, not confirmed; b = Exceptional occurrence; c = Low, sporadic incidence; d = Moderate incidence; e = High incidence; f = Much reduced but still exists; g = Confined to certain regions.

Field experience suggests that the duration of the immunity following vaccination is longer than the 12 months originally proposed as a result of laboratory challenge experiments. There is growing evidence that this vaccine can control CBPP and that if used correctly over a period of years can lead to the eradication of the disease.

In addition there are available certain antibiotics whose use can contain CBPP. Experiments with severely diseased animals have shown that they can be apparently cured with these antibiotics. However, these drugs are *NOT* recommended for routine use in a field outbreak because there may be a risk of creating "chronic carriers" or of inducing resistance in the microorganism. Nevertheless, a stock of these antibiotics should be kept in case of emergency and there should be no hesitation in using them if normal procedures fail to limit an outbreak or in circumstances where the animal health service cannot impose the necessary control measures.

Therefore, although CBPP remains potentially second only to rinderpest as a dreaded and persistent killer, the use of an effective vaccine over the last 10 years has reduced its economic impact on the cattle industry, and the availability of active antibiotics to control adverse reactions has inspired confidence in those fighting against it.

Planning a campaign. Although many aspects of CBPP remain to be studied, the technology for its control is well known and has been successfully applied in several countries.

The physical problem of control in the field calls for:

- The availability of vaccines, equipment, vehicles, etc.;
- The presence of staff trained in special techniques;
- Administrative competence;
- The motivation of the animal health service to apply control;
- The political will to back the operation;
- The acceptance by cattle owners of the measures involved in the campaign, and their positive collaboration.

It is essential to consider the state of social development of the country at the planning stage; a feasibility study is needed to decide the level of intervention desirable.

Various CBPP control measures have been applied in different countries during the last 150 years and there exists a history both of failures and successes. Most failures in the recent past, especially in African countries, have been associated with over-ambitious plans that paid insufficient attention to the local level of animal husbandry and the social acceptability of the measures. An inevitable result of such misconceived schemes has been that, once a campaign ceases, there is a gradual reversion to the previous state.

Mbororo cattle are shy of strangers and much time and patience, and the full collaboration of the owners are required to vaccinate these herds. Even so, the vaccination rate of 200-300 animals per day by a team of four persons is relatively slow, increases the cost, and reflects the difficult conditions.

It appears therefore necessary not only to decide the technical methods for CBPP control but also to break these measures down into stages so that control may be phased in according to the husbandry, environment and social background of the region concerned.

All too frequently harsh measures such as slaughter have been advocated for CBPP control. When such steps are implemented cattle owners resist them; corruption and evasion result and often CBPP reappears quickly in many centres having been spread by owners fleeing the quarantines, etc.

Proposals for elimination of CBPP need to be related to the region in

which it is hoped they may be applied. Where there exist long land frontiers and extensive movements of cattle due to migration, transhumance or trade, talk of "eradication" is premature; this will come when each of the countries whose cattle industries are interrelated have the disease under control within their own boundaries.

A specific country approach to CBPP control is normally dictated by the type of terrain, the economic production of the area and the competence of the animal health service. Semi-arid areas with a low level of production usually have a loose administrative control and the animal health service can do little more than gather information about the prevalance of the disease. Most savanna zones have a service able and sufficiently equipped to carry out some herd vaccination. Intensive animal production areas are likely to have competent services that can intervene quickly on a large scale.

The sequential pattern of CBPP control programmes should be as follows:

- Collection of information and statistics;
  Location of disease outbreaks on the ground.
- Vaccination of infected herds;
  Vaccination of in-contact and neighbouring herds.
- Prophylactic vaccination programme involving ring or barrier vaccination.
- Widespread vaccination campaign if conditions suitable.
- Application of other measures:
  - Follow-up operations involving cattle movement control and quarantine restrictions;
  - Diagnostic testing and seeking out the disease;
  - Slaughter to eliminate any occasional outbreak — but this should never be done without paying adequate compensation;
  - Introduction of legislation in keeping with disease-free status.

Education, publicity and training are essential ingredients of any such programme.

Conclusions. After infection with CBPP some cattle may develop persistent lesions and they can spread the disease for some months without succumbing themselves. These "chronic carriers" represent the major factor preventing eradication in countries where veterinary services are inadequate and where there is nomadic, transhumant or extensive movement of commercial cattle. Hence the need for long-term planning.

Vaccine made from an attenuated culture of *M. mycoides* Strain T1/44 is invaluable in preventing CBPP. It has been used in many African countries on millions of cattle and its outstanding qualities as an immunological agent are widely recognized. Although other strains of the organism have been employed effectively, evidence suggests that disease outbreaks have sometimes resulted from use of less attenuated strains. In certain cases attenuation has been carried too far, so that vaccines have been deficient in immunizing properties.

Some breeds of cattle (e.g., Baoulé, N'dama) are considered to be more susceptible to *M. mycoides* than others; thus it is advisable to carry out initial trials before undertaking any widespread vaccination campaign.

Post-vaccinal reactions occasionally occur as subcutaneous swellings at the inoculation site; these reactions are a function of the dose of viable organisms inoculated and the immunological susceptibility of the cattle being vaccinated. Such reactions are always undesirable and one must ensure that they are quickly recognized and that medical supplies are available to treat them. This is an essential part of the vaccination programme.

As already mentioned, the treatment of diseased animals is never recommended because of the possibility of creating "chronic carriers"; but in particular cases when, for whatever reasons, cattle owners are suspected of trying to conceal the disease or to flee, the Veterinary Service must consider whether ultimate aims are not better served by supervised treatment with effective antibiotics. However costly this may seem ($US6 per animal), it is much less expensive in the long term than allowing widespread dissemination of the disease. This is a difficult decision for those responsible. Recourse to such measures was never necessary during the campaign in the Central African Empire.

CBPP is comparatively easy to control given three essential factors:

- *The collaboration of the cattle owners:* a positive effort must be made to understand and appreciate the human values involved and respect these in any action undertaken. There will always be recalcitrants but schemes should have the approval of the majority. Radio programmes are an important means for keeping the largely illiterate pastoralists well informed — it is most advisable that pastoralists should be adequately consulted before policy decisions are made.
- *The motivation of the animal health service:* an animal health service often stands midway between "the administrator" — the representative of a distant government — and the cattle owners. Inconsiderate action by those in authority may easily rupture delicate relations that have been carefully built up between veterinary staff and livestock owners. Added complications may arise when service personnel are drawn from tribes traditionally resented by the cattle owners, thus making it more difficult to create an atmosphere of mutual trust.
- *Statement of intent by the government* with a guarantee for the provision of funds for a control programme (by whatever means these may be raised, e.g., external aid programmes or cattle-owners' cooperatives). Cattle owners wish to be rid of the scourge of CBPP, which has for so long brought them distress and heavy losses. Animal health services are well advised to recognize this motivation, and to use it to maintain a constant vigilance to uncover outbreaks and to strive continuously to achieve the cooperation necessary for straightforward and effective control of the disease leading to its eventual eradication from the African continent. ■

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Fattening crossbred and zebu cattle on local feeds and by-products in Ethiopia

P.B. O'Donovan

In many tropical countries most of the cattle feed requirements originate from native pasture of low productivity, which is often in a steadily deteriorating condition. Some liveweight gain is achieved during the wet season, followed by variable losses through the dry season. However, if a higher animal offtake were possible, grazing pressure would be reduced and more animals could be fattened.

The kind and quantity of supplementary feeds, both roughages and concentrates, that may be utilized for cattle fattening operations are therefore important. The ratio of roughages to concentrates will have a direct bearing on this, since a 1:1 concentrate/roughage ratio is desirable to promote satisfactory rates of liveweight gain.

An estimate of the total quantity of supplementary feeds suitable for ruminant livestock available in Ethiopia revealed that the concentrate/roughage ratio was only about 1:19 (O'Donovan, 1978), thus showing that only a fraction of the available roughage could be utilized for cattle-fattening operations. Nevertheless, possibilities do exist for a more effective use of the variety of feeds available in the country. At present, crossbred (European × zebu) cattle constitute only a small percentage of the total cattle population, but research and development projects open possibilities for significant increases in their numbers; the resulting male progeny represent a potential source of good quality beef. Although the zebu breeds gain less rapidly than the crossbreds, they will probably continue to supply a large percentage of the beef market.

Native hay closed off in June/July is ready for harvesting in October (end of rainy season) when hay-making conditions are favourable.

Baled hay is shown stacked and ready for feeding to animals; this was the roughage source for some of the trials.

This article describes the main findings of investigations on beef fattening carried out in Ethiopia, with both crossbred and zebu cattle. The feeds utilized were those most important in different regions of the country. Some of them are common to a number of other developing countries, but where this is not the case, the Ethiopian experience may be valuable in suggesting alternative feeds that may be substituted to give equally satisfactory results.

Rations. The 14 rations tested are shown in Tables 1 and 2. Rations 1,

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2 and 3 in Table 1 included native hay as the source of roughage. It was harvested during the early part of the dry season (October/November) and fed unchopped to cattle; the predominant species were *Hyparrhenia* and *Andropogon*. Maize cobs comprised 40 percent of ration 4; the cobs were soaked overnight in water and thereafter fed, with molasses, to cattle. Maize stalks comprised 30 and 50 percent respectively of rations 5 and 6; the stalks were cut after they had wilted in the field and then transported and stacked near the feeding site, where they were chopped before feeding.

The composition of diets 7 to 14 is shown in Table 2. The control diet, number 7, contained 40 percent of maize silage, while diets 8 and 9 had 40 percent of maize stalks and maize cobs respectively. Teff straw (*Eragrostis abyssinica*) and haricot bean halms formed 20 percent each of ration 10. The objectives of feeding diets 11 to 14 were to compare two types (maize stalks and maize cobs) and two levels (35 and 50 percent) of maize residues in fattening diets.

Boran (foreground) and Horro cows represent two important zebu types for crossbreeding with exotic sire breeds. The male crossbred progeny were used in most of the fattening trials described here.

TABLE 1. **Diets in which native hay and maize residues constitute the roughage sources**
(Percentage)

Ingredients	Diet number					
	1	2	3	4	5	6
Native hay	30	30	50	—	—	—
Maize cobs	—	—	—	40	—	—
Maize stalks	—	—	—	—	30	50
Cane molasses	20	—	—	10	—	—
Ground maize	—	20	—	—	43	18
Wheat middlings	20	18	15	17	—	—
Niger oilcake	28	30	33	30	25	30
Bone-meal	1.5	1.5	1.5	2	1.5	1.5
Salt	0.5	0.5	0.5	1	0.5	0.5
Crude protein	14.9	16.4	16.0	15.3	13.5	13.4

NOTE: A trace mineral/vitamin supplement was added to each diet. All diets are expressed on an air-dry basis, i.e., approximately 90 percent dry matter. The crude protein percentages are based on feed dry matter.

TABLE 2. **Diets containing two types and two levels of maize residues**
(Percentage)

Ingredients	Diet number							
	7	8	9	10	11	12	13	14
Maize silage	40	—	—	—	—	—	—	—
Maize stalks (chopped)	—	40	—	—	35	50	—	—
Maize cobs	—	—	40	—	—	—	35	50
Teff[1] straw	—	—	—	20	—	—	—	—
Haricot bean halms	—	—	—	20	—	—	—	—
Cane molasses	20	15	15	15	10	10	10	10
Cracked maize	12	12	12	12	20	—	20	—
Sunflower cake	25	30	30	30	32	37	32	37
Meat and bone meal	—	—	—	—	2	2	2	2
Bone meal	2	2	2	2	—	—	—	—
Salt	1	1	1	1	1	1	1	1
Crude protein	13.8	13.7	13.3	15.2	15.2	15.8	14.9	15.4

NOTE: A trace mineral/vitamin supplement was added to each diet. All diets are expressed on an air-dry basis, i.e., approximately 90 percent dry matter. The crude protein percentages are based on feed dry matter.
[1] *Eragrostis abyssinica*.

For 10 of the 14 rations used, molasses was mixed with the roughage or sprayed over it to promote a satisfactory feed intake. Cracked or ground maize was only sparingly used, mainly because of its first priority as a human food. The main energy feeds consisted of wheat by-products such as middlings and bran, while protein was supplied by niger oilcake (noug cake, *Guizotia abyssinica*) or sunflower cake.

The principal criteria determining the selection of feeds were: that their supply was plentiful and therefore their utilization was of maximum national importance; that they consisted, for the most part, of such by-products as have little or no importance for human and non-ruminant nutrition; and that their low cost (owing to the absence of alternative uses for them) permits the formulation of inexpensive rations that afford the best possible opportunity for economic beef production.

Animals. Most of the animals used in the investigations were crossbred male progeny resulting from the cross-

Purebred male zebu also perform satisfactorily when fattened for up to 3 months prior to slaughter. Part of a large feedlot for this purpose is shown here.

breeding research programme conducted at the various stations of the Institute of Agricultural Research. The crossbreds were produced by using three sire breeds (Simmental, Friesian and Jersey) on three local zebu breeds (Barca, Boran and Horro). At the commencement of the investigations on fattening, the bulls varied from weaning age (6 months) to 21 months; the majority, however, were 8 to 13 months old and were assigned to the different treatments on the basis of breed type and age.

The objective of some of the early experiments was to compare the performance of different crossbred types when fed a common diet, but in subsequent trials more than one diet was given. The limited numbers of each crossbred type of animal available at any particular time dictated the use of unequal numbers. It was desirable to have zebu control animals included in each experiment but, due to restrictions on space, this was feasible only in a few instances. Uncastrated bulls were always used, except in one trial where there were both castrated and entire zebus. But for one experiment involving individual feeding of the animals, group feeding was practised throughout.

TABLE 3. **Rate of gain of the different crossbreds when fed a common diet**[1]

Classification	First experiment (112 days) Daily gain (kg)	Second experiment (112 days) Daily gain (kg)
General mean	1.09 (24)	1.17 (24)
Sire breed		
Simmental	1.18 **a** (8)	1.32 **a** (8)
Friesian	1.11 **ab** (8)	1.29 **a** (8)
Jersey	0.97 **b** (8)	1.14 **a** (8)
Dam breed		
Boran	1.12 **a** (11)	1.24 **a** (9)
Horro	1.06 **a** (13)	1.33 **a** (6)
Barca	—	1.18 **a** (9)

Sire breed × dam breed subclasses	S	F	J	S	F	J
Boran	1.22 (4)	1.08 (4)	1.04 (3)	1.33 (3)	1.25 (3)	1.13 (3)
Horro	1.14 (4)	1.14 (4)	0.89 (5)	1.45 (2)	1.39 (2)	1.15 (2)
Barca	—	—	—	1.17 (3)	1.23 (3)	1.15 (3)

Source: O'Donovan **et al.** (1978).
NOTE: **a, ab, b.** Within the same main classification any two means followed by the same letter do not differ from each other significantly ($P < 0.05$) using Duncan's new multiple range test.
S = Simmental; F = Friesian; J = Jersey.
Numbers of animals are shown in parentheses.
[1] Diet 1 of Table 1.

Animal performance on native hay and concentrates. The composition of native hay is dependent on many factors. In the experiments reported here, native hay had a mean crude protein content of about 5 percent, with only small fluctuations. Using such hay as the base, balanced diets that contained at least 14 percent protein were formulated. The results of the first two experiments are shown in Table 3. In the first experiment, Simmental crosses gained only slightly more than the Friesian crosses (1.18 v. 1.11 kg daily gain) while the Jersey crosses gained significantly less. Daily feed consumption was also highest for the Simmental crosses and the rate of gain was positively related to feed intake. As was to be expected, the Jersey crosses consumed the least feed, but did so with the least efficiency. Both Simmental and Friesian crosses required 7.4 kg feed per kg liveweight gain while the Jersey crosses required 8.4 kg feed. Bulls out of Boran dams gained faster than those out of Horro dams.

The performance of bulls in the second trial exceeded that in the first, with the Simmental crosses again gaining marginally faster than the Friesians (1.32 *v.* 1.29 kg per day).

The Jersey crosses were once again the poorest. Feed conversion was 8.0, 8.2 and 8.4 for the Simmental, Friesian and Jersey crosses respectively. Differences in liveweight gain due to sire breeds were not significant.

The results of the individual feeding experiment, in which two diets containing 30 and 50 percent native hay were fed to cattle, are shown in Table 4. Crossbreds gained significantly ($P < 0.01$) faster than zebu, with a significant sire breed × dam breed interaction. The superior gains of Friesian crosses were due largely to the high gains of Barca × Friesian crosses. Higher gains and higher feed intake were recorded with the 30 percent hay diet than with the 50 percent hay diet; feed conversion was also better. The zebu consumed less feed than the crossbreds and converted it less efficiently into liveweight gain.

Use of maize residues as roughages. Maize is an important crop in a number of developing countries where much of the grain is used for human consumption. Of the crop residues, maize stalks (leaves, stems and husks) account for about 38 percent of the dry weight of the aerial part, while maize cobs constitute another 12 percent (Leask and Daynard, 1973). The extent to which these roughages could form part of properly balanced beef-fattening rations is a matter of economic importance. There is a simultaneous need to determine the most practical means of channelling these low-quality roughages into fattening systems.

The results of initial trials conducted with maize residues are shown in Table 5. In these trials, maize cobs constituted 40 percent and maize stalks either 30 or 50 percent of complete rations. Average daily gains were highest for the Friesian crosses that were offered the 40 percent maize cob ration; this was due mainly to better gains by the Friesian × Barca crosses. Average feed intakes were 8.7, 8.6 and 8.1 kg for the Simmental, Friesian and Jersey crosses, with corresponding feed conversion rates of 9.0, 7.9 and 8.7. Satisfactory gains were observed with the 30 and 50 percent maize-stalk diets. Daily gains were significantly ($P < 0.01$) higher for bulls out of Boran dams than out of Barca dams. Daily gains were significantly ($P < 0.05$) better on the 30 percent roughage diet than on the 50 percent one; the sire × dam × diet effect, although marked, did not reach significance. Feed conversion was also somewhat better on the low-

TABLE 4. Mean values for daily gain, feed intake and feed conversion when diets 2 and 3 were fed individually (third experiment — 182 days)

Classification	Mean		
	Daily gain (kg)	Feed intake (kg/animal/day)	Feed conversion (kg feed/kg gain)
Pure v. crossbred			
Pure	[1] 0.70 (8)	6.10	[2] 9.19
Crossbred	0.86 (16)	6.53	7.64
Boran v. Barca			
Boran	0.67 (4)	5.77	9.00
Barca	0.73 (4)	6.43	9.38
Friesian v. Simmental crosses			
Friesian crosses	0.91 (8)	6.73	7.42
Simmental crosses	0.83 (8)	6.34	7.85
Boran v. Barca crosses			
Boran crosses	0.87 (8)	6.71	7.75
Barca crosses	0.86 (8)	6.36	7.52
Sire × dam interaction			
Boran × Simmental	[1] 0.88 (4)	[1] 6.84	[2] 7.72
Boran × Friesian	0.85 (4)	6.58	7.78
Barca × Simmental	0.74 (4)	5.84	7.98
Barca × Friesian	0.98 (4)	6.88	7.08
Diets			
Number 2	[1] 0.92 (12)	[1] 6.90	[2] 7.55
Number 3	0.70 (12)	5.88	8.75
Diet × breed interaction			
Diet 2 purebred	0.83 (4)	6.59	8.00
Diet 2 crossbred	0.96 (8)	7.05	7.32
Diet 3 purebred	0.57 (4)	5.60	10.38
Diet 3 crossbred	0.77 (8)	6.02	7.96
General mean	0.81 (24)	6.39	8.15

NOTE: Numbers of animals are shown in parentheses.
[1] $P < 0.01$. — [2] $P < 0.05$.

roughage diet; averaged over crossbreds, it worked out at 7.4 and 8.2 kg feed per kg gain for the 30 and 50 percent maize-stalk levels respectively.

A second series of trials was conducted to compare maize stalks with maize cobs; maize silage served as control; and two levels (35 and 50 percent) of both maize stalks and maize cobs were fed (Table 6). Zebu steers and bulls were used in the first trial and both crossbred and zebu bulls were used in the second. There was no significant difference in daily gain between animals fed maize stalks and those fed maize cobs, while, as might be expected, animals fed maize silage gained significantly faster. Bulls gained consistently more than steers, and crossbreds (0.91 kg) significantly more than zebu (0.68 kg). The mean daily gain on maize stalks was 0.76 kg and on maize cobs 0.83 kg. Gains at the 35 and 50 percent roughage levels were 0.80 and 0.79 kg respectively.

TABLE 5. **Mean daily gains for crossbred groups when fed diets 4 (experiment 4) 5 and 6 (experiment 5)**

(Kilograms)

Dam breed and diet	Sire breed: Simmental	Friesian	Jersey	Mean
Experiment 4 (98 days)				
Barca	0.99	1.17	0.97	1.04
	(4)	(5)	(2)	
Boran	0.94	0.95	0.92	0.94
	(4)	(3)	(6)	
Mean	0.97	1.06	0.95	
Experiment 5 (112 days)				
Boran				
Diet 5	0.96	0.97	1.09	
	(3)	(3)	(3)	0.93
Diet 6	0.86	0.88	0.83	
	(4)	(3)	(3)	
Horro				
Diet 5	0.93	0.77	0.81	
	(3)	(3)	(3)	0.81
Diet 6	0.67	0.81	0.84	
	(2)	(3)	(3)	
Mean	0.85	0.86	0.89	

Source: Gebrewolde **et al.** (1978).
NOTE: Numbers of animals are shown in parentheses.

TABLE 6. **Rate of gain, feed intake and feed conversion of crossbreds and zebu fed diets 7 to 14**

Item	Diets: 7	8	9	10	11	12	13	14	Mean (diets 11-14)
Average initial weight (kg)	210.0	209.2	208.3	212.9	205.5	197.4	192.4	212.1	201.8
Average final weight (kg)	309.5	268.5	278.7	285.3	294.4	278.6	283.4	305.3	290.4
Average daily gain (kg)	1.18	0.71	0.84	0.86	0.79	0.72	0.81	0.83	0.79
Crossbreds	—	—	—	—	0.93	0.81	0.93	0.95	0.90
Zebu	—	—	—	—	0.65	0.64	0.69	0.75	0.68
Daily feed intake (kg)	9.6	7.7	7.8	7.6	7.4	7.6	7.2	7.9	7.5
Crossbreds	—	—	—	—	8.1	8.0	7.2	8.0	7.8
Zebu	—	—	—	—	6.6	7.3	7.1	7.8	7.2
Kg feed/kg liveweight gain	8.1	11.0	10.0	8.9	9.3	10.5	8.8	9.5	9.5
Crossbreds	—	—	—	—	8.6	9.8	7.7	8.5	8.6
Zebu	—	—	—	—	10.2	11.4	10.3	10.5	10.6

Source: O'Donovan and Gebrewolde (1978b).
NOTE: The number of animals on each of the diets 7, 8, 9 and 10 was six (three Boran bulls + three steers); the corresponding number on diets 11, 12, 13 and 14 was eight (four crossbreds and four zebu — predominantly Boran). The duration of the former experiment was 84 days and of the latter 112 days.

Other roughages in the diet. There is a variety of other roughages, besides those considered above, that can form part of balanced rations. Such roughages include straws of different crops, which are low-quality feeds but which can be well utilized when included at low to moderate levels in fattening rations (O'Donovan, 1971, 1975). There is an abundant supply of rice straw in some countries and of wheat and barley straw in others. Although they are used to some extent as animal feed, particularly during the dry season, supplementary feeding is limited in both quantity and quality. As a result, they are poorly utilized and total nutrient intake is generally insufficient even to maintain body weight. Liveweight gain on straw-based diets can be achieved with liberal concentrate supplementation; but if maintenance only is desired (as for example during the dry season), a relatively high straw/concentrate ratio would suffice.

The type of ingredients chosen for incorporation in balanced rations depends on their availability locally in adequate quantities, their possible alternative uses industrially (and consequently their costs in relation to their nutritive values), and other considerations such as their ease of feeding and whether processing is needed. If roughages low in dry matter are produced seasonally and a year-round feed supply is to be ensured, it may be expedient to feed the roughages fresh as and when they are available, and to conserve (as silage) some for subsequent use. The mode of utiliza-

tion to realize maximum exploitation is of paramount importance. Satisfactory results were obtained in fattening trials with straw-based rations when adequately supplemented.

A by-product generally in limited supply is sisal waste. It has a dry-matter content of 10 percent or less and a high fibre and low protein content. Even when supplemented with relatively large amounts of concentrates, daily gains were only of the order of 30 g (O'Donovan and Gebrewolde, 1978a). Sisal waste may be regarded as a feed best suited for maintaining liveweight or preventing large weight losses when there is little alternative fodder.

Significance of findings. Although the results described here were obtained under particular environmental conditions in Ethiopia, they could very well apply to a wide region of the world. Some of the roughages are common to other countries, while other roughages have counterparts similar in composition. A variety of satisfactory rations can be formulated from these feeds by applying the basic principle of furnishing diets able to meet the nutritional requirements.

Fattening rations only have been considered in the present article, guided by the following criteria: they should be based on by-products, both roughages and concentrates, that are available in abundance and therefore of economic importance; there are few alternative uses to which they can be put, besides ruminant feeding; they should be available at low cost; they should have been known from previous research to promote acceptable liveweight gains; and they should be easy to feed, conserve and store. These criteria are of great importance when considering the use of nationally produced by-products. Maize grain was included in the present trials in only a few rations, and then at low to moderate levels because of its demand as a human food. In all of the low energy feeds used, very satisfactory rates of liveweight gain were realized.

Native hay or other low-quality roughages are generally available in many countries. The addition of molasses appears to increase consumption and rate of gain, but acceptable gains were also recorded in its absence. The rather low energy content of the main concentrate ingredients used (wheat bran, wheat middlings) suggests that superior gains are possible with high-energy diets. The inclusion as protein of Niger oilcake, which contains up to 10 percent fat (because of incomplete extraction), increased the overall energy content of the rations.

The possible uses to which maize residues can be put will vary from one region to another. The stage of harvest has a profound influence on subsequent animal performance. Nevertheless, in practice, the most important consideration is not so much the nutritional value of the residue, as the extent to which the residue may conveniently be exploited to obtain maximum economic returns. Allowing the stalks to wilt in the field, as practised in the trials reported here, had the advantage that it facilitated storage without the risk of moulds developing. It also dispensed with harvesting machinery for silage making. The major disadvantage was the considerable reduction in nutritive value compared with harvesting at the green, unwilted stage, which would have allowed the production of good silage. In *intensive* fattening operations, serious consideration should be given to early harvesting and ensiling, but local conditions will dictate the methods of harvesting, storage and feeding that should be adopted. The stalks should be chopped to avoid undue wastage and possible rejection of the fibrous stems.

There is usually some difficulty in getting animals to consume whole maize cobs. In the present experiments the cobs were soaked in water overnight and when fed to cattle with molasses there was no problem of rejection. For all practical purposes the maize stalks and cobs produced the same rate of liveweight gain; earlier harvesting of maize stalks would probably have given this residue a decided advantage over cobs. The addition of molasses served to encourage the consumption of the fibrous residues.

Maize is an important crop for human food in Ethiopia. The residues (maize cobs and stalks) were used in some of the feeding trials.

The scope for intensive fattening of cattle in many developing countries should be judged against the background of the available types and qualities of feeds. While maximum use should be made of high-quality pasture, there is often little of this available and, thus, in the short term at least, the correct combination of by-products (roughages and concentrates) serves the twofold purpose of increasing the output of meat and reducing the grazing pressure on the ranges. In the long term, the total availability of energy and protein concentrates would be the principal determinant of large-scale expansion of cattle fattening enterprises. The use of by-products must not be seen as an end in itself, but rather as complementary to the expansion of pasture-based beef production. By-products can fill vital gaps in the beef-production cycle.

The important role that by-products can play in supporting below-maximum rates of liveweight gain, which, under certain conditions, may take precedence over intensive fattening, has not been considered here. A low level of concentrate supplementation of poor-quality roughages has application in reducing weight losses or even

Crossbred bulls have the potential to gain rapidly and efficiently on diets low to moderate in energy as demonstrated in the experiments described. Shown above (from left to right) are groups of Simmental, Friesian and Jersey cross bulls in one of the fattening trials.

maintaining weight during the dry season. There is a variety of feeding regimes to be adopted throughout the life cycle of animals, dictated by the target weight at slaughter envisaged and the rates of gain achievable at minimum cost during different seasons.

Considerations for future development. Although research data are lacking on a number of aspects of animal production in the developing countries, this should not impede our efforts to move a stage further in formulating and testing different production systems or parts of systems. If assumptions prove to be 75 percent correct, it signals a major step forward. Further refinements can be realized by the subsequent injection of missing data or by improving upon existing information. It also helps to test out more widely the results of research from a particular institute or station; an added advantage of this would be its impact on the farming community as a demonstration.

Despite the fact that research results may be incomplete for a particular country, data are often available from another country with a very similar climate, and with comparable pasture types and feeding and management regimes. From these, a close universal approximation can be made, for example, on the rates of liveweight gain of zebu calves from birth to weaning and at subsequent stages until slaughter, as influenced by various factors such as season of calving, pasture availability and quality in different seasons of the year, and type of supplementary feeds used. The formulation and testing of systems and their components have the further advantage of guiding research along lines that are likely to be both practical and fruitful.

Conclusions. This article has dealt in broad outline with the results of fattening experiments in which a variety of diets were fed to crossbred and zebu cattle. The very satisfactory rates of liveweight gain attainable from a mixture of ingredients (roughages and concentrates), aimed at meeting the nutritional needs of the animals in question, have been pointed out. Practically all the ingredients were produced locally in adequate amounts, were low in cost and had few alternative uses.

In many countries there is a wide variety of by-products that can be exploited for feeding cattle. As a first step it is necessary to identify the types and quantities of these by-products and to investigate how they can be suitably combined to meet various production needs. By-products do not replace the need for cultivating high-quality fodders; rather, they supplement the latter when supply is short. The overall aim should be to derive viable systems of production taking into account all the resources, including feed.

While it is recognized that research results are in short supply in many developing countries, this ought not to frustrate efforts toward the application of the best available information. This short-term approach, in the expectation of more accurate data through continuing research, if properly planned and executed, could go a long way toward increasing the output of animal products. It should be remembered in this context that the principles of animal production remain unchanged; the vital shortcoming is in the correct application of these principles to suit local conditions. ■

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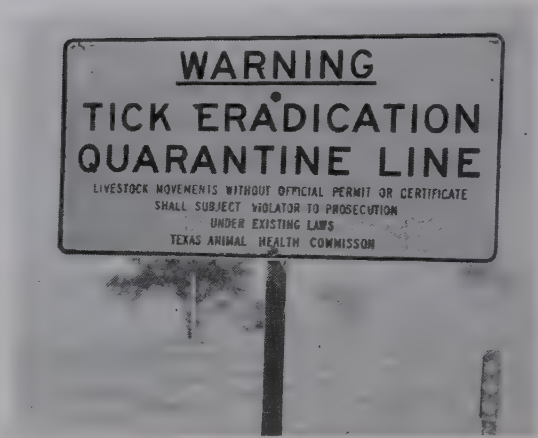
Eradication – an alternative to tick and tick-borne disease control

R.A. Bram and J.H. Gray

Introduction. Ticks, generally regarded as the ectoparasites that cause the greatest economic losses to livestock production in the world today, adversely affect livestock hosts in several ways (Snelson, 1975): they contribute to unthriftiness and anaemia by exsanguination; they damage hides and subject livestock to secondary infection; they cause toxicoses and paralysis by the injection of their salivary secretions; and, most importantly, they transmit pathogenic agents that cause diseases, many of which result in debility and death. Of the many tick-borne livestock diseases, four are of particular concern: bovine anaplasmosis, bovine babesioses, theilerioses, and heartwater. The economic impact of ticks and the diseases they transmit is enormous. Not only is the annual global cost of ticks and tick-borne diseases estimated to run to thousands of millions of dollars, but also mankind is deprived of a significant amount of animal protein that cannot be replaced from other sources (Bram, 1975; Callow, 1975; Drummond *et al.* 1978; Snelson, 1975).

To counteract the adverse effects of ticks and tick-borne diseases, a variety of tick-control programmes have been integrated into modern livestock management practices. Foremost among these is chemical tick-control, which not only decreases the detrimental effects of the ticks themselves, but also interrupts the transmission cycle of pathogenic agents and, thus, reduces the incidence of tick-borne diseases. Depending on the tick species involved, the livestock-management practices followed, the tick-borne diseases present, and the environmental conditions of an area, cattle are treated at periodical intervals with any one of over 30 available acaricides. The frequency of acaricide treatment may vary from every 3 or 4 days in East Africa for the protection of cattle against East Coast fever transmission by *Rhipicephalus appendiculatus* to intervals approaching 6 months for the reduction of *Boophilus microplus* populations. In addition to the chemical control of ticks, increased efforts are being made to introduce tick-resistant breeds of livestock that, though they continue to support tick populations, are not conducive to massive tick infestations. The control of tick-borne diseases is also accomplished by the use of live, attenuated vaccines. Noteworthy are the vaccination programmes for tick fever (a disease complex caused by *Babesia bovis, B. bigemina*, or *Anaplasma marginale*) in Australia (Callow, 1978) and the development of an East Coast fever vaccine (consisting of strains of *Theileria parva*, and *T. lawrencei*) by an FAO regional project located at Muguga, Kenya. In addition, live attenuated vaccines have been used in programmes to control heartwater (caused by *Cowdria ruminantium*) and tropical theileriosis (caused by *Theileria annulata*) (Uilenberg, 1975; Wilde, 1978).



Quarantine is an essential tool in tick eradication.

Certainly, any investments in organized tick and tick-borne disease control are economically sound. A recent cost-benefit analysis of cattle-fever tick (*Boophilus* spp.) control in the United States resulted in a 1:98 ratio. That is, for every $1 spent on tick control, there is a $98 return. Howver, tick control itself implies a perpetual annual investment that imposes a continual, and sometimes unnecessary, drain on livestock production. A control philosophy, therefore, is a philosophy of living with ticks and tick-borne diseases.

Eradication - an alternative. An alternative philosophy is one of living without tick-borne diseases and their vectors through a major eradication effort. Whereas the cost-benefit ratio for cattle-fever tick control in the United States was determined to be 1:98, the cost-benefit ratio for eradication was 1:140. Thus, resources devoted to successful eradication in this case would result in approximately

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NOTE: Mention of a proprietary product or a pesticide in this article does not constitute an endorsement or recommendation by the US Department of Agriculture or by FAO.

1907

1915

1925

1935

1940

1943

The progress of Boophilus *tick eradication in the United States, 1907 to 1943*

a 40 percent greater return on investment than would tick control

To be successful, certain preconditions must be met before eradication can even be considered. Foremost is the need for a broad base of scientific knowledge about the biology and host relationship of the tick species in question, the epidemiology of the disease complex to be eradicated, and the techniques for tick eradication. In addition, an eradication philosophy requires strong support from the livestock industry (usually stimulated by economic considerations), a favourable legal and political climate, and a long-term commitment of manpower and financial resources. Finally, whereas tick control can be accomplished with varying degrees of effectiveness by the efforts of individual livestock producers working independently, eradication depends upon the existence or creation of a comprehensive animal health infrastructure with programme policies that are uniformly applied to all segments of the livestock industry. If none of these conditions are fulfilled, an eradication effort could fail.

A number of tick-eradication efforts have been attempted in several parts of the world (Graham and Hourrigan, 1977). One successful example that can be cited is the eradication of cattle-fever ticks, *Boophilus* spp., and bovine babesiosis from the continental United States. In 1907, an area of approximately 1 813 000 km² was infested with *Boophilus* spp. At that time, a Federal/State cooperative programme to eradicate cattle-fever ticks was initiated with a general strategy of beginning on the northern edges of the infested area and moving southward. Through a centrally planned and coordinated programme of quarantine, compulsory dipping of cattle, and/or pasture vacation, the campaign gradually progressed to a successful conclusion by 1943. The success of this effort has been attributed to several factors: the fact that *B. microplus* and *B. annulatus* are one-host ticks with limited host range; a strong animal health infrastructure at the Federal, State, and county levels; a sound manpower, financial, political, and legal base of support; and innovative research before and during the eradication campaign. Although all these factors contributed to eradication, in the final analysis credit for the success must be given to the cattle owners themselves, who enthusiastically demanded, supported, and participated in tick eradication. The benefit to the livestock industry of the United States has been a savings estimated to exceed $1 thousand million per year.

[1] The results of the cost-benefit analyses developed for the conditions that exist in the United States may not be as favourable in other countries; however, such analyses should be performed to assist in making decisions regarding tick control and eradication.

The most thorough, effective method of acaricide treatment is the total immersion of livestock in a dip-vat.

Programme planning and application. In planning and executing a national tick-eradication campaign, five major programme components contribute to a coordinated effort: surveillance, extension and training; quarantine; treatment; and research and development.

A tick-eradication campaign begins and ends with surveillance. Surveillance defines the initial area of tick infestation and determines the prevalence and distribution of the diseases ticks transmit. Surveillance monitors campaign progress and provides the day-to-day information upon which eradication decisions are based. And surveillance guards against the re-establishment of tick infestations in eradicated areas. The techniques of tick surveillance naturally vary with the tick species in question. With one-host ticks, such as *Boophilus* spp., the detection of all parasitic stages is accomplished by manual inspection of the host. This technique, known as "scratching", is applied to all animals in an eradication effort, not just to a statistical sample. Other surveillance techniques that have been employed, particularly for two- and three-host tick species, include dragging, live-trapping, manual examination of mammalian or avian alternate hosts, and trapping with carbon dioxide bait (Gladney, 1978). After collection, tick specimens must be officially identified by competent authorities at a central laboratory where centralized records are maintained for analysis and programme evaluation.

Extension and training are the foundations of eradication. "Extension" includes all educational efforts directed toward the livestock producer and the industry in general; "training" covers the instruction of eradication campaign personnel. Thus, to achieve success through the cooperation, support, and participation of the stockman (even when temporary inconveniences or financial hardships are encountered) an extension effort usually begins prior to actual programme implementation and continues throughout the eradication campaign. The livestock producer will cooperate best when he understands why eradication is necessary, how eradication will be accomplished, and what eventual eradication will mean to the industry in general and to himself in particular. Similarly, personnel at all levels of the eradication organization can function effectively only with a clear understanding of the importance of their own responsibilities and how they relate to both the eradication campaign and the livestock industry. Training should strive to achieve efficient execution of duties and the uniform application of programme policies. It should also emphasize to programme managers the necessity of utilizing all available operational resources in the most effective

manner through conscientious supervision.

Quarantine, never a popular component of any animal health programme, is an essential tool in tick eradication. Since ticks spread to new areas primarily by the movements of their mammalian hosts, the control of livestock movements through effective quarantine can render a dynamic distributional pattern static while tick eradication proceeds. Both area and premises quarantines have their place in an active campaign. As the name implies, area quarantines prohibit livestock movements out of large, infested areas without prior inspection and precautionary treatments in order to prevent the spread of ticks. Premises quarantines apply to individual ranches or pastures that are defined by recognizable physical barriers that prevent livestock and ticks from crossing under ordinary circumstances. Premises quarantines must be strictly enforced until ticks within the quarantine boundaries have been unquestionably eradicated. The utilization of quarantine techniques implies the existence of an adequate legal foundation and sufficient manpower to monitor or enforce, when necessary, the controlled movement of livestock.

The actual killing of ticks is usually accomplished by applying acaricide directly to the domestic host of the ticks. The most thorough, effective method of acaricide treatment is the total immersion of livestock in a dip-vat (Drummond, 1975). Although other methods of acaricide application, such as spray races, spray-dip machines, hand spraying, and hand dressing, have been employed under special circumstances, the dip-vat continues to be the principal eradication tool in most situations. In fact, utilization of dip-vats is so important that the success or failure of an eradication effort may depend on the quality of dip-vat management practices. Foremost among these management practices is the systematic treatment of all livestock in a quarantine area on a regular schedule determined by the biology of the tick species and the local environmental conditions.

Whereas effective tick control can be accomplished by a well-planned dipping schedule (basically, dipping livestock at intervals in order to kill the most ticks with the least effort), eradication is based on a rigid, systematic dipping schedule that can compensate for the biological variation within the tick population as well as for occasional instances of human error. For example, the *Boophilus* eradication programme in the United States prescribes dipping all livestock on infested premises at 14-day intervals for 9 months. In addition to a systematic dipping schedule, the acaricide within the dip-vat is continually maintained at the maximum safe concentration to kill ticks. Again, using the United States *Boophilus* eradication programme as an example, an official dipping with one of the permitted acaricides, coumaphos, requires a dip-vat concentration of from 0.125 to 0.250 percent active ingredient (in most parts of the world, coumaphos is used for tick control at a concentration of approximately 0.03 percent). Furthermore, the acaricide concentration within the vat is sampled before, during, and after each dipping operation. There is also the requirement that the dip-vat be emptied, cleaned and recharged when there is over 10 percent suspended matter in the acaricide, when the number of animals treated exceeds two per 4 litres (approximately) of acaricide in the dip-vat, or when the acaricide has been in the dip-vat for longer than 240 days.

Technical support of dip-vat management is provided by a chemical laboratory that not only conducts routine confirmatory analyses of acaricide concentrations, but also develops the

The routine determination of dip-vat concentration and contamination is vitally important to proper dip-vat management. Here a tick inspector is carrying out these tests in his office.

For best results, dip-vats must be emptied, cleaned and recharged at prescribed intervals.

essential data that are used by programme managers in selecting approved acaricides and formulations. In small-scale efforts to eradicate two- or three-host ticks, techniques of ground application of acaricides have been employed to kill non-parasitic stages. However, such procedures are usually only considered with newly introduced, exotic species that have not spread appreciably beyond the point of original introduction.

Livestock management practices have also been incorporated into campaigns to eradicate ticks. In the case of a one-host tick such as *Boophilus* spp. pasture vacation (or pasture spelling) has been applied to good advantage to kill larval ticks by starvation due to the absence of their host for approximately a 9-month period. This technique of tick eradication assumes the existence of well-fenced pastures and the absence of suitable alternate hosts. As with dip-vat treatments, pasture-vacation schedules must be rigidly enforced.

Research and development precede the initiation of eradication and continues until its successful conclusion. It has been estimated that the level of research and development support should approach 10 percent of the operational programme budget. Probably the major research commitment would be concentrated prior to and during the meticulous planning necessary for eradication, whereas developmental studies and field applications would increase during the course of the campaign. Major areas of research and development have included: all aspects of tick biology, particularly under the variety of environmental conditions found in an eradication zone; ticks and tick-borne disease epidemiology which, in effect, is a combined developmental and operational function; eradication technology, particularly as it relates to new acaricide products, formulations and methods of application; and the continual monitoring for acaricide resistance in the tick populations. In order to apply results of research and development to best advantage, the campaign should be sufficiently flexible to incorporate new information into operational procedures and policies.

Eradication and control. Although eradication is one alternative to the control of ticks and tick-borne disease, it is not necessarily the best option in all circumstances. In fact, in many situations, a well-planned and supported control effort precedes eventual eradication. In other instances, decentralized, individual control activities are most appropriate.

Thorough agitation of a dip-vat before treating cattle is an important factor in proper dip-vat management.

All livestock leaving an infested premises must be treated with acaricide to prevent the spread of ticks.

Certainly, an eradication campaign for ticks and tick-borne disease requires an effort that far exceeds the resources needed for control. It is based on a substantial, long-term financial and manpower commitment. It is also based on a strong animal health infrastructure supported by the regulatory authority to enforce quarantine measures and to require the systematic treatment of all livestock. In addition, after success has been achieved in a geographic area, sufficient authority and resources are necessary to prevent the re-introduction of the eradicated tick species and disease(s). As eradication approaches realization, large livestock populations become highly susceptible to tick-borne diseases. Should the campaign falter or be abandoned at this point, an epidemic of major proportion would ensue due to enzootic instability. Eradication does not always require a national effort. On the contrary, areas of eradication could be limited to regions, states, or even individual holdings provided that the capability exists to prevent the re-introduction of ticks after eradication has been achieved.

Varying degrees of control can be accomplished either on an individual-producer basis or by a centrally planned and coordinated programme. The utilization of live vaccines (when available) can also be successfully incorporated into a control scheme. Regrettably, by their very nature, tick-control programmes seem inevitably to meet problems associated with tick resistance to acaricides. As a result, farsighted control-planning would, hopefully, include provisions for reducing dependence on acaricide treatments

by consideration of alternative tick-control methods (Wharton, 1976).

The decision, therefore, to initiate the eradication of ticks and tick-borne disease is influenced by a complex array of interacting parameters: the biology of the tick species and the epidemiology of the diseases involved; the economic impact of the ticks and tick-borne disease(s); and the availability of government financial and other resources over a number of years; the existence or creation of a functional animal health infrastructure; the legal authority to enforce strict quarantines and systematic treatment-schedules; and the enthusiastic commitment of the livestock industry itself. Perhaps a phased approach to national control and eradication of tick-borne disease is most logical. For example, the Mexican tick campaign (Fideicomiso Campaña Nacional Contra la Garrapata) is designed in three phases — the promotion phase, the control phase and the eradication phase. Thus, different areas of the country are designated as promotion zones, control zones, eradication zones, or free zones, and the programme policies and activities in the different zones vary depending on the objectives. As objectives are successfully attained, the zone status is progressively changed to a new phase with the application of appropriate policies, activities and resources.

A spray-dip machine in operation. This method of treating livestock conserves water and the equipment is portable.

Conclusions. The eradication of tick-borne livestock diseases and their vectors is a viable alternative to the control of ticks and tick-borne disease. However, the assessment of this alternative deserves the consideration of a variety of interrelated parameters that will eventually influence the success or failure of a campaign. Although in many situations eradication may not be an attainable national goal, successful examples of the eradication of ticks and tick-borne diseases illustrate that under the proper conditions, with the necessary resources and commitment, it is possible and economically sound. Perhaps the most logical approach to national control and eradication of tick-borne diseases is a progressively phased programme that can accommodate zones of no control, promotion, control, eradication and, finally, free zones. ■

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Chemical defleecing as a method of harvesting wool from sheep

P.J. Reis and B.A. Panaretto

The removal of the fleece from sheep is a skilled operation and is usually performed with shearing machines. Owing to a number of factors, including the expense of shearing, the Australian Wool Corporation is encouraging the investigation of alternative methods for harvesting wool. One such method is chemical defleecing, which may be defined as the use of chemicals either to disrupt the process of wool growth temporarily, or to weaken the wool already grown, so that the fleece can be removed without the use of conventional shearing machines.

Several criteria need to be met before any chemical can be used as a practical defleecing agent. It must be safe, cheap, reliable, and easily administered. Safety must include absence of hazards to the operator, toxicity to the sheep and harmful chemical residues that may be present in milk or left in the carcass after slaughter. In addition, loss of wool production should be minimal and there should be no adverse effects on the wool grown following treatment. It must also be possible to incorporate the procedure into acceptable methods of sheep management.

At least two approaches to chemical defleecing may be envisaged:

- Wool fibres may be attacked by the external application of a compound that dissolves them near the surface of the skin. Such a process has been used to remove wool from localized areas of skin (Ferguson, Laws and Hopkins, 1976). However, numerous difficulties can be envisaged in using this process to remove the whole fleece. In particular, the difficulty of restricting treatment to the base of the fleece makes it unlikely that this method will succeed;
- The process of wool growth may be disrupted by the internal administration of a suitable compound. This approach seems to be more likely to succeed, and it will be considered in more detail here.

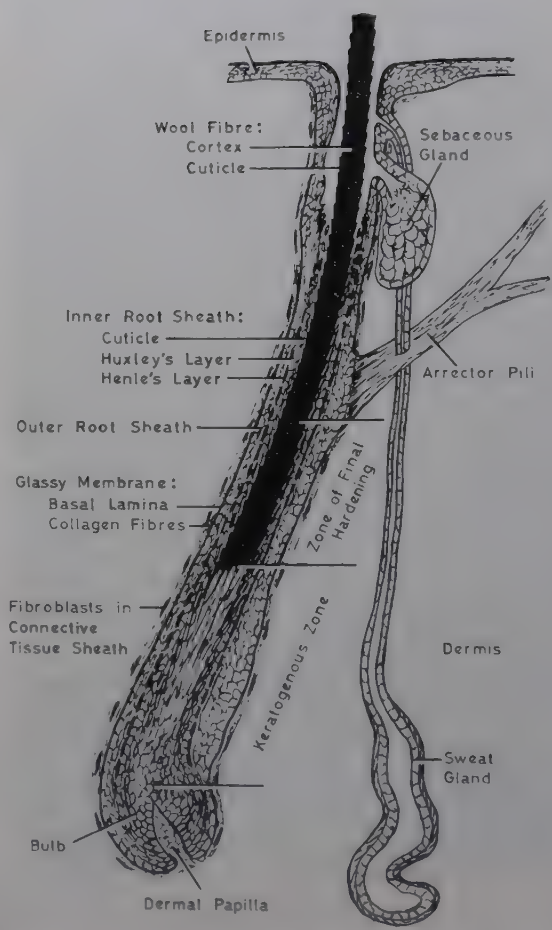

Figure 1 *A primary wool follicle and its associated structures. Secondary wool follicles, which are frequently branched in Merino sheep, do not have a sweat gland or an* arrector pili *muscle.*
(Photo: R.E. Chapman, CSIRO)

Targets in the wool follicle. The normal process of fibre production will be mentioned briefly, before discussing the various chemicals that may be considered as potential chemical defleecing agents. Most wool follicles on sheep normally used for wool production are actively growing a fibre at any given time, i.e., they are in the anagen stage of fibre growth. A diagrammatic representation of a primary wool follicle growing a non-medullated fibre is shown in Figure 1. At least five potential targets may be considered for chemical defleecing agents:

- The bulb where deoxyribonucleic acid (DNA) replication and cell division take place;
- The keratogenous zone, where there is active synthesis of ribonucleic acid (RNA) and proteins. Cells produced in the bulb grow and are modified to form the wool fibre, the inner root sheath and part of the outer root sheath. The oxidation of the thiol-rich proteins of the fibre commences in this zone, with copper possibly acting as a catalyst. Near the upper limit of this zone DNA and RNA are largely degraded and resorbed;
- The zone of final hardening, in which the oxidation of the thiol groups and formation of the fibre are completed;
- The inner root sheath, which is intimately associated with formation of the fibre cuticle, and which is unusual in that its proteins contain the amino acid citrulline;

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• The intercellular cement in the fibre.

Several of the potential chemical defleecing compounds studied so far are antimitotic agents and act on the follicle bulb cells. Since any dividing cells are likely to be affected by these compounds, they would not be specific to the wool follicle. Of the processes involved in fibre growth, the synthesis of particular wool proteins provides perhaps the best target for specific chemical defleecing agents. It may also be possible to disrupt the intercellular cement or the formation of the proteins of the inner root sheath.

Figure 2 *A sheep defleeced 12 days after dosing with a substance that caused a complete break in the fleece. Note that the skin is completely bare, apart from the extremities.*

Types of compounds known to interfere with wool growth. Compounds that are known to interfere temporarily with fibre growth may be considered in two groups:

- Physiological compounds that either control the natural cycles of hair and wool growth, or influence wool growth when supplied in either deficiency or excess;
- Foreign compounds that are not normally involved in the physiological processes of sheep.

Defleecing agents may produce various effects that can be described as follows: a complete break in the fleece, in which virtually all fibres are shed

Figure 3 Top *The opened fleece of a sheep about 2 months after it had been treated with a cortisol analogue. Most wool fibres have been shed (sf) and new fibres (rg) are emerging at the skin's surface. A small number of continuous fibres (cf) retain the fleece on the sheep.* Middle *In order to harvest the fleece at this time, the continuous fibres are disrupted.* Bottom *The defleeced animal resembles a conventionally shorn sheep.*

from the follicle canal so that the fleece is cast (see Figure 2); a partial break in the fleece, in which only a proportion of the fibres is shed — the fleece is retained by the continuously growing fibres, and can be harvested subsequently by breaking them (see Figure 3); the growth of weakened wool, in which some or all of the fibres show a zone of weakness.

Natural shedding in sheep. Seasonal shedding of the fleece is evident in many primitive or unimproved breeds of sheep. The marked seasonal variations in wool growth observed in some modern domestic breeds is possibly a vestige of this process. In adequately fed Merino sheep a cyclic shedding process is confined to the hairy parts of the body (Hutchinson, 1965).

In sheep where natural shedding of wool fibres occurs, a visible moult takes place during the shedding cycle, usually in spring and early summer during a period of increasing day-length. The shed fibres have been replaced by new growth. Basically, the follicles show three stages of activity: an extended phase of continuous fibre growth (anagen) is followed by a relatively short, intermediate phase (catagen), which is followed by an extended quiescent phase (telogen), during which no fibre growth occurs. Telogen usually extends from early winter to early spring. The fibre that is to be shed is held in the telogen follicle as a brush-end fibre; a group of cells (a germ) from which the next fibre will generate lies beneath this. The brush-end fibres are shed following the emergence of the new fibre, thus ensuring that the sheep is not naked as a result of the moult (Ryder, 1974).

The physiological processes, including those involving endocrine hormones (which control the natural process of shedding), are not well understood. However, hormones secreted by the thyroid, adrenal, pineal and pituitary glands, and the gonads can modify the moulting process in mammals (Mohn, 1958). With a better understanding of the process of natural shedding it may become possible to harvest wool by inducing shedding using physiological doses of appropriate hormones. Accordingly, research in this area is being undertaken at the Commonwealth Scientific and Industrial Research Organization (CSIRO).

Alterations in the supply of physiological compounds. Deficiencies or excesses of various physiological compounds can cause marked weakening of wool or hair, and in some cases either partial or complete loss of the pelage. Such effects have been observed with vitamins, trace elements, amino acids, and adrenal glucocorticoids, and it may be possible to utilize some of these compounds for chemical defleecing.

Excessive amounts of vitamin A can cause alopecia in humans (Levantine and Almeyda, 1973), and a reduced supply of water-soluble vitamins (probably B complex) has been observed to cause loss of wool in lambs maintained solely on a synthetic liquid diet (J.L. Black and R.E. Chapman, unpublished).

The supply of certain trace elements is known to influence processes involved in wool growth. The effects of excess selenium, as selenium-containing amino acids, will be discussed below under foreign compounds. Copper deficiency produces "steely" wool which has a low intrinsic strength (Underwood, 1977), and zinc deficiency can cause partial or complete loss of hair in monkeys (Macapinlac *et al.*, 1967) or of wool in sheep (Mills *et al.*, 1967; Underwood and Somers, 1969).

Figure 4 *Scanning electron micrograph of a distorted and partially degraded wool fibre produced during the abomasal infusion of methionine into a wheat-fed sheep. The bar line represents 20 μm.*

Figure 5 *A weak band (b) in the fleece of a sheep that received an abomasal infusion of a mixture of amino acids lacking in lysine.*

Attempts have been made to disrupt wool growth by the administration of chelating agents such as ethylenediaminetetracetic acid, to cause a temporary deprivation of elements such as copper and zinc (A.M. Downes and P.J. Reis, unpublished). Although a complete break in the fleece, and subsequent defleecing, was achieved in some sheep with this treatment, the amounts required were too close to the lethal dose to encourage further work.

Amino acids. Variations in the supply of certain amino acids, produced by infusion into the abomasum of sheep, can result in the growth of weakened wool. Two types of treatment have produced this effect.

First, wool growth is inhibited and the fibres become very weak when infusions of methionine are given to wheat-fed sheep (Reis and Tunks, 1974). The weakness appears to be related to distortion and partial degradation of the fibres before emergence from the skin (Chapman and Reis, 1978) and allows the fleece to be pulled from the sheep when the damaged portions of the fibres have emerged (Figure 4). This effect is in contrast to the stimulation of wool growth obtained when methionine infusions are given to roughage-fed or grazing sheep.

Second, the abomasal infusion of a mixture of amino acids imbalanced by the lack of lysine or methionine causes a marked reduction in the rate of wool growth and a substantial weakening of the fibres (Reis and Tunks, 1976, 1978a). The weak band resulting (Figure 5) allows the fleece to be pulled from the sheep. In contrast, the abomasal infusion of a complete mixture of essential amino acids stimulates the rate of wool growth.

Adrenal glucocorticoids. Early literature concerning the stimulatory effects of adrenalectomy on quiescent hair follicles and the inhibitory effects of adrenal glucocorticoids on active hair follicles has been reviewed by Mohn (1958). Following the observations of Lindner and Ferguson (1956) that adrenocorticotrophic hormone and cortisone inhibited wool growth, similar effects were shown for cortisol (Chapman and Bassett, 1970; Thwaites, 1972). In most of these experiments the hormones were administered over a period of several weeks, but the extent and duration of the elevation of glucocorticoids in plasma required to inhibit wool growth were not known. However, the feeling that high concentrations of cortisol have to be maintained over long periods in order to inhibit hair follicles is supported by the observations of Singh and Hardy (1975) who reported that 75 μg cortisol/ml culture medium were required over 6 days in order to cause the regression of hair follicles in cultured foetal mouse skin.

The observations with adrenal glucocorticoids have led to research on the use of some synthetic analogues of cortisol — dexamethasone and flumethasone — as chemical defleecing agents. This research is discussed in the following section.

Foreign compounds. Many chemicals are known to interfere with hair growth and to induce partial or complete loss of hair (Levantine and Almeyda, 1973). Iljin (1936, 1938) showed that a single oral dose (10-14 mg/kg body weight) of various salts of thallium caused casting of the fleece in several breeds of sheep. However, these compounds have not been investigated further as defleecing agents, presumably due to their high toxicity. The use of cyclophosphamide (an anticancer drug) as a chemical defleecing agent for sheep has been investigated extensively, following the initial observations of Dolnick *et al.* (1969) and Homan *et al.* (1969). A single oral dose of 25-30 mg/kg body weight is sufficient to allow defleecing of most sheep. However, cyclophosphamide is also toxic and the substance has not been incorporated into any practical commercial system of wool harvesting.

Other substances that induce loss of hair (in mice) include the selenium-containing amino acids, selenocystathionine and selenocystine (Palmer, 1968; P.J. Reis, D.A. Tunks and S. Munro, unpublished), but no experiments have been carried out with sheep due to the toxicity and high cost of these chemicals.

Three classes of foreign compounds have been investigated recently at CSIRO as potential chemical defleecing agents for sheep, and some results of this research are summarized in the following sections.

Analogues of cortisol. Some analogues that are much more potent than cortisol, as judged by several conventional tests, inhibit wool growth (Ferguson, Wallace and Lindner, 1965; Panaretto *et al.*, 1975). The concentra-

tions of these compounds in plasma could not be measured in these experiments. With the advent of suitable assay methods, most recently radioimmunoassay, it has been possible to measure plasma concentrations of adrenal glucocorticoids and their analogues in sheep and to relate these to the effects observed on wool growth.

Recent experiments have shown that dexamethasone and flumethasone are potentially useful as chemical defleecing agents (Panaretto and Wallace, 1978a, b). These compounds induced shedding of most wool fibres on Merino sheep with the formation of brush-ends on the shed fibres, as observed in natural shedding (Figure 3). In order to achieve this result in most sheep, a total dose of 8.5 mg dexamethasone/kg body weight 0.75 or 1.3 mg flumethasone/kg body weight 0.75 was given as a continuous intravenous infusion for 8 days. These infusions resulted in plasma concentrations of dexamethasone or flumethasone of 40-50 and 8 mg/ml respectively. Wool growth was depressed to 15-20 percent of its pretreatment level and regrowth had emerged from the skin 30 days after the end of treatment. The same dose of flumethasone given orally, or subcutaneously, induced insufficient fibre shedding to allow removal of the fleece (Panaretto and Wallace, 1978b).

There are a number of difficulties in using these substances as defleecing agents. The doses that must be used (135 mg dexamethasone or 21 mg flumethasone, given over 8 days to a 40-kg sheep) are expensive. Considerable variation in the extent of shedding can occur, both between animals and between anatomical regions. Experiments with synergists to flumethasone indicated that these difficulties can be partially overcome (Panaretto and Wallace, 1978c). Sheep consuming a maintenance diet lost about 3 weeks' wool growth as a result of treatment (Panaretto and Wallace, 1978a), although more prolonged inhibition of wool growth has been observed in some experiments (Panaretto *et al.*, 1975).

Treatment of sheep with analogues of cortisol in the way discussed above produces effects somewhat similar to natural fibre shedding. Thus, these compounds may provide a possible method of inducing fibre shedding and hence wool harvesting. However, many problems remain to be solved before this can be done.

Mimosine and related compounds. The amino acid mimosine, which occurs in high concentration in the seeds and foliage of the tropical legume *Leucaena leucocephala,* caused loss of the fleece and toxic effects when administered to sheep (Hegarty, Schinckel and Court, 1964). Controlled intravenous infusion of mimosine at a rate of at least 80 mg/kg body weight/day for 1½-2 days consistently caused the temporary cessation of wool growth without toxic side-effects, and allowed subsequent manual removal of the fleece (Reis, Tunks and Chapman, 1975). This treatment maintained a concentration of minosine in blood plasma of at least 100 μmol/1. Single oral doses of mimosine were usually effective in producing a complete break in the fleece when larger doses (400-600 mg/kg body weight) were given (Reis, Tunks and Downes, 1978) to compensate for the degradation of mimosine to 3,4-dihydroxypyridine in the rumen (Hegarty, Schinckel and Court, 1964). The effectiveness of mimosine as a defleecing agent was influenced by the nutrition of the sheep; high food intakes necessitated a larger dose of mimosine (Reis and Tunks, 1978b; Reis, Tunks and Downes, 1978).

While there is evidence that mimosine may have several modes of action that could influence wool growth, it appears to act mainly by arresting cell division in the follicle bulb (Hegarty, Schinckel and Court, 1964; Ward and Harris, 1976). Wool-fibre growth stopped for a period of 10-12 days within 2 days of dosing with mimosine (Reis, Tunks and Chapman, 1975; Reis, 1978). The rate of wool growth was enhanced in the early regrowth following defleecing, and fibre diameter was still above pretreatment values 11 weeks after dosing (Reis, 1978; Reis, Tunks and Downes, 1978). This enhanced growth rate may compensate, at least in part, for the period of follicle inactivity.

Mimosine can also produce a partial break that would allow subsequent removal of the fleece with the aid of some mechanical device. Some oral doses and intravenous infusions, given in amounts slightly below those required to stop fibre growth, cause the majority of fiibres to shed, but some fibres continue to grow and retain the fleece. However, this effect cannot be produced predictably. The intravenous infusion of mimosine at a rate substantially below a defleecing dose (20 mg/kg body weight/day) causes the growth of weakened wool. Fibre diameter is drastically reduced after infusion for at least 10-12 days and the fibres become very weak and altered in structure (Figure 6). Most fibres continue to grow, and when treatment is stopped wool growth rapidly recovers and is temporarily stimulated.

Although various analogues of mimosine have been shown to inhibit DNA synthesis in sheep skin (Ward and Harris, 1976), and several of these have caused hair loss in mice (Panaretto, Tunks and Munro, 1978), only one, "isomimosine", has been shown to allow subsequent defleecing of sheep (Reis, Tunks and Downes, 1978). However, this analogue offers no advantages over mimosine as a defleecing agent.

Mimosine appears to be an effective defleecing agent under controlled laboratory conditions. There are no adverse effects on subsequent wool growth and little loss of wool growth occurs. The compound is rapidly excreted from the body and no harmful metabolites appear to be formed. It is a naturally occurring compound and is already widely consumed by cattle in some areas. However, there are several problems associated with its practical use as a defleecing agent. It is difficult to envisage that sufficient quantities for large-scale use can be obtained by extraction or organic synthesis. The size of an oral dose required is large (at least 16 g for a 40-kg sheep), difficult to administer, and is influenced by the nutrition of the sheep. Mimosine is not a completely reliable defleecing agent. The compound is toxic and the margin between an effective and a lethal dose is narrow. It is also unsafe to dose ewes after day 85 of pregnancy (R.J. Scaramuzzi and B.A. Panaretto, unpublished).

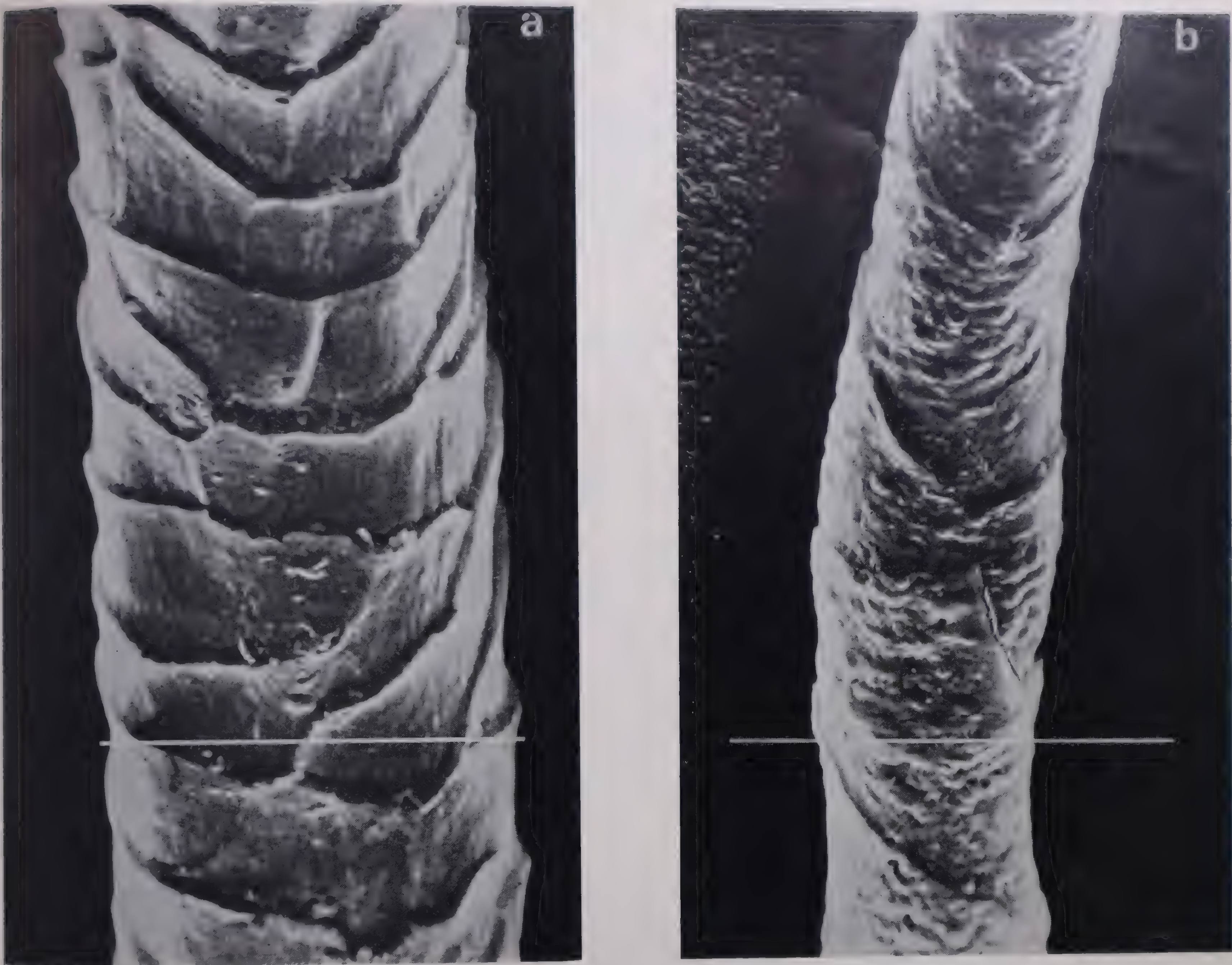

Figure 6 *Scanning electron micrographs of the same wool fibre (a) prior to treatment and (b) after 20 days of an intravenous infusion of mimosine at a rate of 20 mg/kg body weight/day. The bar lines represent 20 μm.*

1-P-AMINOPHENOXY-5-PHTHALIMIDOPENTANE AND RELATED COMPOUNDS. Hughes (1959) reported that a side-effect of administration of the antischistosomicidal drug, 1-p-aminophenoxy-5-phthalimidopentane, to sheep was complete loss of the fleece. Further research has been carried out at CSIRO to test the potential of this compound as a chemical defleecing agent. Experiments with sheep proved it to be a reliable defleecing agent when given as a single oral dose at a rate of 400 mg/kg body weight. However, temporary blindness was observed in some sheep 1 or 2 days after dosing, particularly when doses larger than 400 mg/kg were given. Many related compounds have been synthesized in several CSIRO laboratories and tested for defleecing activity. Work is continuing in the search for an active compound without adverse side-effects.

Animal husbandry aspects of chemical defleecing. When a complete break in the fleece is produced after dosing with a chemical, the fleece is usually cast from the sheep within 2 to 3 weeks of dosing, before new fibres have regrown sufficiently to provide protection from the environment. The animal is often completely bare at this time, apart from the extremities, and is, therefore, susceptible to climatic stress, in particular cold and sunburn (see Figure 2). In order to avoid loss of wool prior to harvesting and to protect the sheep from the environment, two options are available. In the first, the fleece is harvested before any wool is shed, and the bare sheep must then be protected, either by housing indoors or by some form of protective coating outdoors. As indoor housing would be impracticable for most free-ranging flocks, research into various types of protective coating is being undertaken at CSIRO. In the second option, a coating is placed on the sheep at the time of dosing to retain the cast fleece until there is sufficient regrowth of wool to provide protection. So far, attempts to retain the fleece for a sufficient period have not been successful. This option does not appear promising.

The problems of loss of wool and the protection of bare sheep apparent in the above options may be avoided by using treatments that produce a partial break or weakened wool. In these situations the fleece is retained

and harvesting can be delayed until sufficient growth of wool has occurred to protect the sheep. However, the removal of such fleeces is frequently difficult and research is being undertaken at CSIRO into appropriate means of harvesting them.

Conclusion. It is certainly possible to remove the fleece from sheep following the administration of chemicals that interfere with the process of wool growth. However, the task of finding a compound to fit all the criteria listed earlier and of solving the associated animal husbandry problems in order to devise an economically viable system of wool harvesting is indeed a formidable one. No immediate recommendations can be made concerning the use of chemical defleecing agents in practice. It is difficult to devise ways of interfering with wool growth without a sufficiently detailed understanding of the steps involved in the formation of wool fibres. More research is needed to give a greater understanding of the mechanism of wool growth and the factors controlling cyclic activity of wool follicles. ■

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Current situation and outlook for selected livestock products and animal feeds[1]

M.B. Dale

In January 1979 the FAO commodity review and outlook 1977-79 *was published, containing chapters on meat and milk, as well as on a number of commodities that play an important role in animal feeding. This article is a summary of selected parts of the Commodity Review as well as an assessment of conditions relating to certain aspects and characteristics of the feed sector. The feed estimates used were established after a careful analysis of the information available in FAO.*

Meat

World meat production in 1978. The *FAO commodity review and outlook* reports that in 1978 world beef output fell for the first time since 1971 while the production of sheep and goat meat levelled off. Although the output of pig and poultry meat increased considerably, the expansion of total meat production slowed to only 1.6 percent (Table 1). The decline of cattle numbers was particularly marked in the United States and Australia although there was also a slight fall in the total for developing countries. In Europe and the USSR, where most beef is produced from dairy herds, both cattle numbers and beef output increased slightly (Table 2).

Preliminary estimates indicate that the output of sheep and goat meat rose in developing countries, but production fell in Oceania where the long drought of earlier years resulted in smaller sheep flocks and in considerably lower output of sheep meat.

The production of pig and poultry meat expanded worldwide, reflecting a rising demand for these meats as other meats became scarcer and more expensive. This expansion was assisted by ample feed-concentrate supplies at prices favourable to livestock producers. The growth in the output of pig and poultry meat was particularly rapid in the USSR, eastern Europe, Japan, and developing countries.

Price trends in 1978 reflected the supply/demand position. Beef prices in the United States and in exporting countries rose sharply, while mutton and lamb prices remained at the high levels reached in 1977. Mainly as a consequence of high beef prices, pig and poultry prices in North America recovered from their depressed 1977 levels although in western Europe the high output, which exceeded domestic demand, kept prices under some pressure.

TABLE 1. **Production of the main types of meat**
Million tons[1]

Meat type	1976	1977	1978 (estimated)	Estimated direction of change 1978 on 1977 *Percentage*
Bovine	48	48	47	—2
Sheep and goat	7	7	7	(slightly down)
Pig	42	44	45	+2
Poultry	23	24	26	+8
World total	120	123	125	+1.5

Source: FAO Commodity Review and Outlook, 1977-79.
[1] In terms of carcass weight. Figures rounded to the nearest million.

World meat consumption in 1978. World meat consumption in 1978 increased more rapidly than production, leading to some decrease in stocks. Meat consumers in eastern Europe and the USSR continued to benefit from stable — often subsidized — retail prices while consumption was also subsidized in some of the richer developing countries. In Japan, shortage of fish supplies helped to raise the demand for meat.

International trade in meat. The volume of the international trade in meat changed little in 1978 though there was a further rise in value terms. However, the patterns of trade continued to change. One of the principal factors in the rise of the world meat trade in recent years has been the growing import demand in the Near East and in some other relatively high-income developing countries. It is estimated that imports of meat in all forms by members of OPEC were of the order of 800 000 tons in 1978, or about seven times more than in the

This article has been provided by the FAO Commodities and Trade Division, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

[1] As of March 1978.

early 1970s. However, in the second half of the year, the largest buyer in this group of countries, Iran, had substantially reduced its purchases.

On the other hand, due to increased meat supplies in the USSR and eastern Europe in 1978 this group of countries became once again a net exporting region.

Outlook for meat output. The Commodity Review and Outlook anticipates that, short of unforeseeable changes in the feed and animal-health situation, world meat output will continue to grow slowly in 1979. Once again, nearly all the increase will be in pig and poultry meat. The expansion of the output of pig and poultry meat is expected to remain strong in Japan and in many of the developing countries and will probably accelerate in the United States. However, it could slow down slightly in the USSR and eastern Europe.

Beef output in North America and Oceania is likely to decrease in 1979 as the cyclical rebuilding of herds will not be reflected in higher meat output until later years. Increased beef production in other parts of the world will not be able to balance this shortfall. The rebuilding of sheep flocks in Oceania will also take time. While investment in sheep and goat production in developing regions appears to have been stimulated by the growing import demand in the Near East, this development will bear fruit only in the longer run.

The reduction of beef output in North America and Oceania suggests further rises in international beef prices during 1979. These increases could be limited, however, by the ample supplies of poultry and pig meat as well as by consumer resistance to price increases.

In the sheep-meat sector prices in 1979 will probably remain firm. In contrast, prices of poultry and pig meat in international trade are likely to remain low.

Milk and milk products

Growth in production in 1978. The growth of world milk production slowed down in 1978 following the effects of adverse weather on 1977/78 feed supplies in the USSR, Oceania, parts of Europe and Latin America. In North America the decrease in cow numbers was partly due to the steep rise in slaughter cattle prices. Policy measures, such as the EEC's dairy cow reduction programme, limitations of milk-price guarantees through quota systems (in Austria, Canada and Switzerland), and a decrease in the real value of milk support prices (North America and several western European countries) helped to limit the growth in world output.

In the EEC, the slight reduction in dairy cow numbers was more than offset by productivity gains due to the increased use of balanced formula feeds and the rapid spread of higher yielding dairy breeds. Production also continued to rise in eastern Europe and Japan.

Among manufactured milk products there was a worldwide increase in cheese production in 1978 whereas the expansion in the output of butter, condensed milk and milk powder slowed down.

Demand for milk and dairy products in 1978. The demand for milk and dairy products increased in developing countries, as well as in Japan, eastern Europe and the USSR. It also increased in North America, though not in western Europe. Factors affecting the growth in demand included the slower rise in dairy product prices than in meat prices in many countries, increased welfare distribution in the United States, and continued benefit to consumers in eastern Europe and the USSR from highly subsidized retail prices. Consumption is also increasingly being subsidized in some of the richer developing countries. In western Europe butter consumption, and particularly the use of skim milk and skim milk powder for animal feeding are subsidized.

TABLE 2. **Livestock numbers in major producing areas**
Million head

	1976	1977	1978 (estimated)
CATTLE			
World total	1 338	1 344	1 333
Developing countries, of which:	891	904	902
Argentina	58	58	57
Developed countries, of which:	447	440	431
EEC	79	77	77
Oceania	43	41	38
United States	128	123	116
USSR	111	110	112
SHEEP AND GOATS			
World total	1 437	1 438	1 435
Developing countries, of which:	896	910	911
Argentina	39	37	37
Developed countries, of which:	541	528	524
EEC	46	47	48
Oceania	205	195	191
USSR	147	145	146
PIGS			
World total	638	667	700
Developing countries, of which:	361	370	380
Brazil	36	37	38
Developed countries, of which:	277	297	320
EEC	70	73	76
United States	50	55	57
USSR	58	63	70

Source: FAO Commodity Review and Outlook, 1977-79.

International trade in milk and dairy products. World exports of dairy products in 1978 levelled off after the exceptional 15 percent rise in 1977. The growth of the world dairy trade in recent years has stemmed, to a large extent, from the rising imports of developing countries, particularly those in OPEC, and several countries in North Africa and the Far East.

Owing to rising import demand, prices in the international trade strengthened. The export price of skim milk powder for human consumption, for instance, rose from US$350 per ton f.o.b. in the middle of 1976 to about US$500 in 1978. Nevertheless, prices in the international trade remained well below the level of the domestic market prices in major producing countries.

Outlook for dairy products in 1979. The short-term outlook is for a more rapid expansion in world milk production since a marked rise in milk yields is expected following larger fodder and feed crops in 1978 and the current favourable milk/concentrate feed price ratio in many countries.

The prospects for demand are patchy. While consumption may continue to expand rapidly in Japan, the USSR, and eastern Europe, growth rates may fall in North America and the developing countries. There will be little rise in demand in western Europe. Export supplies from the EEC will remain ample and those from Oceania and eastern Europe could rise again. There is scope for further world import growth but such expansion may be slow. On the whole, the excess of global output over demand in commercial outlets may rise again in 1979. Hence, international trade prices could remain sluggish, stocks increase and the expenditure on milk price support and related measures remain high.

Major feeds

Feed grains. Favourable weather in nearly all producing areas resulted in a record grain harvest in 1978. High per hectare yields were obtained both in the United States and in the USSR. The harvests were also good in western and eastern Europe. Owing to good crop prospects, international market prices for coarse grains began to fall in mid-1978 but the operation of the United States farmer-owned reserve programme led to a stabilization of values by the last quarter of the year.

Favourable livestock/feed price ratios in the United States, record availabilities of grain in the USSR, an accelerated increase of meat consumption in Japan, and rising livestock numbers in the EEC should all contribute to a larger use of grain as animal feed during the 1978/79 season. Coarse grain consumption for feeding purposes should also continue to increase in a number of developing countries (with rapid income growth as a result of rising foreign-exchange earnings from exports) such as the Republic of Korea, Malaysia, Mexico, Iran, Nigeria and Venezuela.

Grain feeding in 1979. While it is too early to estimate feed grain usage in 1979, since major crop failures could influence the results, the favourable ratios of livestock product/feed price and the easy availability of coarse grains and feed-grade wheat point to a further expansion of grain feeding during the current year. The expansion is likely to accelerate in the United States, Japan, the USSR, and in a number of developing countries with growing livestock industries. However, the growth in the EEC's feed grain utilization may be limited by further increases in the use of non-grain feed ingredients, such as green maize used for the feeding of cattle, as well as milling by-products, processed starchy roots, gluten meal and various pulps and by-product meals increasingly used in compound-feed rations for pigs, poultry and dairy cows. In the case of the trade in cassava feedstuffs, this may be restricted by policy action in Thailand and the EEC.

The incentive to use high proportions of non-grain feed in compound rations is largely confined to the EEC where, due to the Common Agricultural Policy, feed grain prices to livestock producers and compounders are considerably higher than in other major user countries, while most non-cereal concentrates enter the market with zero duty or with low levies. In most major livestock producing areas outside the EEC, grain feeding in 1979 is expected to be boosted by:

- The anticipated rapid increase in poultry and pig numbers;
- More intensive concentrate feeding of cattle for slaughter in order to finish the animals at a greater weight and thus take advantage of favourable market conditions;
- Continuation of the trend in the improvement of milk yields by more intensive concentrate-feeding of dairy animals.

Protein feed — output and demand in 1978. The 1978 output of protein [2] from the main oilseeds and from fish meal reached the record level of 36 million tons, about 6 percent higher than the long-term trend. Of this total nearly half was produced in the United States, mainly in the form of soybean meal. Most of the global production increase was accounted for by soybean meal although the output of cottonseed, sunflower, rapeseed and linseed meals has also grown.

International market prices, in terms of United States dollars, remained relatively steady during most of 1978, averaging 215 on the FAO *Price index for total oilcakes and meals* (1964-1966 = 100), or 8 percent below the year before. The depreciation of the US dollar relative to the currencies of many of the main importers meant that the index for 1978 overstated the level of real import prices in many major import markets. Demand was stimulated by lower prices, by a higher output of pig and poultry and by the increasing use of non-cereal energy feeds such as cassava which, in order to balance their lack of protein, require a greater use of protein meals.

Output of oilseed-protein cakes and meals — 1979. Based on information available in February 1979, the output of oilmeal protein in 1979 is forecast to reach a new record of

[2] All output figures in this section are quoted in protein equivalent.

nearly 40 million tons. However, uncertainties remain regarding Latin American crops, which may account for 16 percent of the world output. Of the global output of oilmeal-protein cake and meal in 1979 over 60 percent is expected to be soybean cake or meal and 10 percent cottonseed cake, while fish meal, groundnut cake, sunflower cake and rapeseed cake are each expected to account for between 5 and 8 percent. Increases are forecast in both production and export of soybean, rapeseed, groundnut and sunflower meals, while declines are tentatively forecast in the output of cottonseed, linseed, fish meals and copra cake. On balance the total export availability of protein feeds could rise by over 15 percent.

Some of the main factors influencing protein-feed demand in 1979 will be:

- The continued high level of demand for concentrates to feed dairy cattle, pigs, and poultry in developed countries;
- Strong increases in the protein-feed requirements of Mexico, and several countries in the Near East and the Far East;
- More plentiful grain supplies from domestic output allowing larger quantities to be fed to animals in the USSR and eastern Europe, leading to a higher demand for protein meal to balance the rations.

Protein prices in early February 1979 were, on the whole, slightly higher than the average for 1978. From now on, the key factors affecting international trade prices are likely to be:

- Developments in crop conditions affecting Latin American soybean output in early 1979;
- Prospects for North American oilseed crops to be harvested in late 1979;
- Oilseed imports by China, India, and the USSR.
- Variations in exchange rates between currencies of major exporting and importing countries, since any weakness of the US dollar could make protein imports more attractive in many importing countries.

On the basis of present knowledge, international market prices of oilmeals seem more likely to fall than to rise during 1979. While supplies seem to be ample relative to demand at current prices, consumption is likely to be responsive to lower prices, thus limiting any decline in values.

TABLE 3. **Compound feed production in selected countries**
Million tons

Country	1960	1970	1973	1974	1975	1976	1977	1978 (preliminary)
EEC, total	22.4	47.8	58.5	57.8	58.1	65.4	67.4	71.1
Belgium/ Luxembourg	1.6	4.3	5.0	5.0	4.7	5.1	5.0	5.1
Denmark	0.8	2.6	2.7	2.7	2.9	3.4	3.7	4.1
France	2.2	7.6	11.0	11.1	11.1	12.3	12.5	13.5
Germany, Fed. Republic	3.6	9.7	11.0	10.7	11.5	13.1	14.0	14.2
Ireland	0.3	1.0	1.2	1.1	1.0	1.2	1.4	1.6
Italy	0.8	3.6	6.2	6.4	6.0	7.4	7.8	8.3
Netherlands	4.3	7.9	10.1	10.5	10.7	11.4	12.3	13.5
United Kingdom	8.8	11.0	11.2	10.3	10.2	11.4	10.8	10.8
Austria	—	—	0.8	0.8	0.8	0.9	0.9	...
Norway	0.6	—	1.2	1.3	1.2	1.3	...	...
Portugal	0.1	—	1.5	1.8	1.8	2.2	2.8	...
Spain	0.6	5.3	7.1	7.8	8.4	...	10.8	...
Switzerland	—	—	0.7	0.7	0.7	1.3	1.3	...
Canada	2.3	5.3	8.5	9.4	9.5	9.8	10.2	...
United States	...	56.6	56.8	55.6	62.1	71.6	67.8	...
Japan	2.9	...	18.7	17.7	16.3	18.0	19.5	...
USSR	...	23.7	...	...	41.8	46.3	51.3	56.1

Sources: FEFAC, and FAO based on national statistics.

Compound feed [3]. The expansion in compound-feed use since 1960 has been considerably greater than the growth in grain-feed use and, although appropriate statistics are limited, and the data in many countries poorly defined, Table 3 gives an indication of the reported magnitude and of the growth trends in selected countries. In the developed countries as a whole, expansion was checked during the economic recession of the early 1970s, but output has recovered since 1975. It is estimated that global growth will exceed 5 percent in 1979. The market expansion in those developing countries from which data are available, notably Brazil, Malaysia, Mexico, Nigeria, Republic of Korea, Syria, Thailand, Turkey, and Venezuela, is expected to be 10 percent or more (in some cases over 30 percent), although in some cases from a small base.

The proportions of the components of compound feeds vary from place to place, and also from time to time. In areas where the compounding industry produces mainly complementary-feed mixes for addition to farm-mixed grain, as in parts of the United States and Canada, the proportion of grains used for commercial mixing is low (under 10 percent). Where the industry produces complete feeds and is largely dependent on imported components, the proportion of grains varies according to the relative prices of grains and substitute materials. For instance, in the Netherlands (where substitution has gone the furthest) the percentage of grains in compounds dropped from 33 percent in 1975 to less than 20 percent in 1978. In France, Italy, and the United Kingdom, the share of grains in compounds is of the order of 50 percent. In Japan, the USSR, and in most developing countries, only a narrow range of ingredients is utilized

[3] The data in this chapter refer to balanced or formula feed manufactured by business firms or cooperatives. It does not cover on-farm mixtures.

in locally produced compound feeds, the share of grains being over two thirds of the total.

The components of compound feeds also vary with the type of livestock produced. Poultry and pig feeds contain usually more grain than the compound prepared for ruminants while in many manufactured cattle feed mixes, grains play a small role. In dairy mixes, high-protein feeds are particularly important in order to supplement the bulky and mostly low-protein farm-grown fodder. As recent experience in the Netherlands and the Federal Republic of Germany shows, compounding formulations can be flexible and there are no technical reasons why larger amounts of locally available non-cereal feed components should not be included in the commercial pig and poultry rations made in developing countries, particularly if such components provide digestible energy and protein at a lower cost than that of grains. Indeed, the existence of feed-compounding industries should enable a number of countries to convert many of their low-value, processing by-products, agricultural wastes, and some of their as yet underutilized local crops (root crops, certain pulses, etc.) into high-grade animal feed.

In the longer term, the demand for compound feeds will be influenced chiefly by the following factors:

- The demand for poultry products, pork, and dairy products, i.e., those livestock products whose production normally absorbs an estimated 90 percent of all compound feeds;
- Demand from the "quality-beef finishing sector", particularly at times when beef prices are favourable to producers;
- The spread of intensive-feeding methods leading to the wider use of mixed feeds fortified with vitamins and minerals, which enable livestock producers to buy feed incorporating the latest results of research in animal nutrition, thus giving better conversion ratios;
- The mechanization of animal feeding in specialized production enterprises in which the low bulk and trouble-free handling of feed and its quality consistence are at a premium. ■

NEWS AND NOTES

Editorial change

Owing to an increasingly heavy workload in the other duties for which he is responsible in the Animal Production and Health Division of FAO it has been necessary for Dr P. Mahadevan to relinquish his duties as Technical Editor of the World Animal Review.

Dr Mahadevan served as Technical Editor from June 1973 until the preparation of issue No. 29 of the Review. Over this period he has very successfully maintained the high standards set for the Review and, in spite of the heavy burden involved, has ensured a constant succession of issues each containing material and articles of considerable interest both to developing and developed countries.

Needless to say, Dr Mahadevan's efforts have been much appreciated by everyone connected with the Review, including, we are certain, all the readers of the Review around the world.

Vth International Symposium on Ruminant Physiology

The Vth International Symposium on digestive physiology and metabolism in the ruminant will be held from 3 to 7 September 1979 at the University of Clermont-Ferrand, France.

This symposium is being arranged by a European Scientific Committee with the assistance of an International Advisory Committee. It is sponsored by the French Institut national de la recherche agronomique (INRA). The scientific committee is chaired by Y. Ruckebusch, Dept. of Physiology, Veterinary School of Toulouse, France, assisted by P. Thivend, secretary, INRA, CRZV, Theix, France. The advisory committee is chaired by I.W. McDonald (Chairman of the IVth International Symposium, held in Australia).

The four previous symposia were held in Nottingham (1961), Ames (1965), Cambridge (1970), and Sydney (1974).

This symposium is thus part of a logical sequence which has clearly demonstrated that studies of ruminant digestion and metabolism have, by increasing understanding, encouraged the rapid improvement of the practical procedures of husbandry, and have provided a basis for solution of problems concerned with the productivity and health of domestic ruminants.

The scientific programme at the Vth Symposium will consist of nine sessions: gastrointestinal motility; behavioural physiology and nutrition; the microbial ecosystem of the rumen; ruminant digestion and its manipulation; mineral metabolism; intermediary metabolism; adaptation to the diet; comparative digestive physiology; and a workshop morning. Any correspondence should be addressed to: Secretariat, Vth International Symposium on Ruminant Physiology, ISRP 1979, INRA, 63110 Beaumont, France.

Second Consultation on the Programme for the Control of African Animal Trypanosomiasis, Lusaka, Zambia, 5 to 7 December 1978

This Consultation was attended by 40 experts from African countries and regional organizations and 14 observers from international organizations (IAEA, OIE, UNDP, UNEP, WHO)[1], international research centres (ICIPE, ILCA, ILARD)[2] and assistance agencies, as well as FAO staff from Headquarters, the Regional Office for Africa and field projects.

The Consultation reviewed recent developments in tsetse and trypanosomiasis control techniques, including the rearing of trypanotolerant animals and projects for immunization, and discussed several documents prepared by the FAO Secretariat on the objectives, strategy and implementation of the Programme for the Control of African Animal Trypanosomiasis and Related Development. Current activities and prospects were also reviewed and discussed. The coordination of activities implemented under this programme at national, subregional and international level was discussed in depth, and the management and coordination structures proposed by FAO were endorsed by the

[1] IAEA = International Atomic Energy Agency; OIE = Office international des epizooties (International Office of Epizootics); UNDP = United Nations Development Programme; UNEP = United Nations Environment Programme; WHO = World Health Organization.

[2] ICIPE = International Centre for Insect Physiology and Ecology; ILCA = International Livestock Centre for Africa; ILRAD = International Laboratory for Research on Animal Diseases.

Consultation. Brief reports of activities were presented by participants from African countries, international organizations, international laboratories and assistance agencies concerned.

Nine recommendations were adopted on tsetse control, chemotherapy, rearing of trypanotolerant animals, relationship of animal trypanosomiasis control with sleeping sickness control, training of tsetse control specialists, identification of pilot projects, tsetse area development, coordination and management of the programme.

The final report of this Consultation will be available early in 1979.

Forthcoming events

- The XXIst World Veterinary Congress will be held from 1 to 7 July 1979 in Moscow, USSR.
- The Vth International Symposium on Ruminant Physiology will be held from 3 to 7 September 1979 in Clermont-Ferrand, France.
- The IXth International Congress on Animal Reproduction and Artificial Insemination will take place in Madrid in 1980. Information can be obtained from the President or the Secretary of the Organizing Committee: *President:* Prof. Dr Carlos Luis de Cuenca, Director, Departamento de Genética y Mejora, Facultad de Veterinaria, Ciudad Universitaria, Madrid-3, Spain. *Secretary:* Prof. Dr Tomás Pérez García, Jefe, Departamento de Reproducción Animal, CRIDA-6, Instituto Nacional de Investigaciones Agrarias, Ciudad Universitaria, Madrid-3, Spain.
- The 30th annual meeting of the European Association for Animal Production (EAAP) will be held from 23 to 26 July 1979 in Harrogate, United Kingdom. The period 27 to 29 July will be devoted to excursions, with particular emphasis on pigs and ruminants. More details may be obtained from: The Organizing Secretary, EAAP 1979, c/o Meat & Livestock Commission, P.O. Box 44, Queensway House, Queensway, Bletchley, Milton Keynes MK2 2EF, United Kingdom.
- The 31st Annual Meeting of EAAP will be held from 1 to 6 September 1980 in Munich, Federal Republic of Germany, in connection with the 22nd Session of the International Committee for Recording the Productivity of Milk Animals.
- The 32nd Annual Meeting of EAAP will take place in Yugoslavia in 1981.
- The 33rd Annual Meeting of EAAP will be held in the USSR in 1982.

Conference on Intensive Animal Production in Developing Countries to be held in Harrogate, United Kingdom, from 12 to 14 November 1979

The Conference is being organized by the British Society of Animal Production (BSAP). It is hoped that the Conference will act as a forum to crystallize the problems and solutions relating to intensive animal production in developing countries. In addition to invited comprehensive review-papers to be presented by authoritative specialists, short communications from delegates to be exhibited in "Poster Sessions" running simultaneously with the main programme are also invited. The Conference will be followed by a number of visits to intensive animal production units.

The Conference programme is to be divided into six sections:

- Desirability, constraints and sociological implications of intensifying animal production;
- Influence of climate on intensive animal production;
- Sources and availability of foodstuffs for intensive animal production;
- The role of livestock improvement in intensive animal production;
- Examples of intensive animal-production systems currently in operation;
- Initiation, operation and financing of intensive animal-production schemes.

Hotel reservations will be arranged by the Secretary of the BSAP. Registration forms can be obtained from the British Society of Animal Production, Harvest House, 62 London Road, Reading, Berks. RG1 5AS, United Kingdom.

Livestock activities of the CILSS and the "Club du Sahel"

In September 1973, after consecutive years of drought had most severely affected the Sahel, the Heads of State of Cape Verde, Chad, the Gambia, Mali, Mauritania, the Niger, and the Upper Volta formed the "Comité interministériel de lutte contre la sécheresse au Sahel (CILSS)." The CILSS secretariat is located in Ouagadougou, the Upper Volta.

The main objective of CILSS is to assist the Sahelian countries in using human and technical resources in a coordinated effort to fight the effects of drought and to take measures that should help to limit its ravaging effects in the future. In parallel to this urgent survival operation, CILSS envisages the general development of the region. FAO has cooperated in this field by analysing possible approaches by which the CILSS objectives might be realized (see *Perspective study on agricultural development in the Sahelian countries 1975-1990.* FAO, 1976).

* English title: "Permanent Interstate Committee for the Control of Drought in the Sahel".

In 1975, the Development Assistance Committee of the OECD approached CILSS and suggested the creation of an association of donor countries and organizations which, being on an informal basis, could make the implementation of development programmes and projects more flexible and easy. The sovereign member countries of CILSS accepted the idea and, in 1976, the "Club du Sahel" was inaugurated and its secretariat established in Paris.

The Club du Sahel has been very active during the past two years in organizing working groups or "teams" composed of Sahelian experts, assisted when necessary by expatriate consultants. CILSS-Club du Sahel teams have identified problems and projects in the fields of agriculture (dry-land farming, irrigated crops), livestock production, integrated crop-livestock production, forestry and fisheries. Human resources aspects, marketing problems, education and research requirements have also been tackled, although not in depth. An attempt to define a general agricultural strategy for the Sahel has been made.

When requested by CILSS, FAO has cooperated with the CILSS-Club du Sahel teams and, in particular, with the livestock team, to which the Animal Production and Health Division has made available many consultants. FAO has a permanent liaison with CILSS-Club du Sahel, in order to facilitate reciprocal information and cooperation when possible and required.

CILSS-Club du Sahel is concluding the formulation of first-generation projects which, it is hoped, will soon be implemented with the aid of the Club du Sahel donor members. A second generation of projects is expected to be identified during the forthcoming years in the light of a common Sahelian strategy.

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NOTE: * = In preparation; C = Chinese; E = English; F = French; S = Spanish.

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